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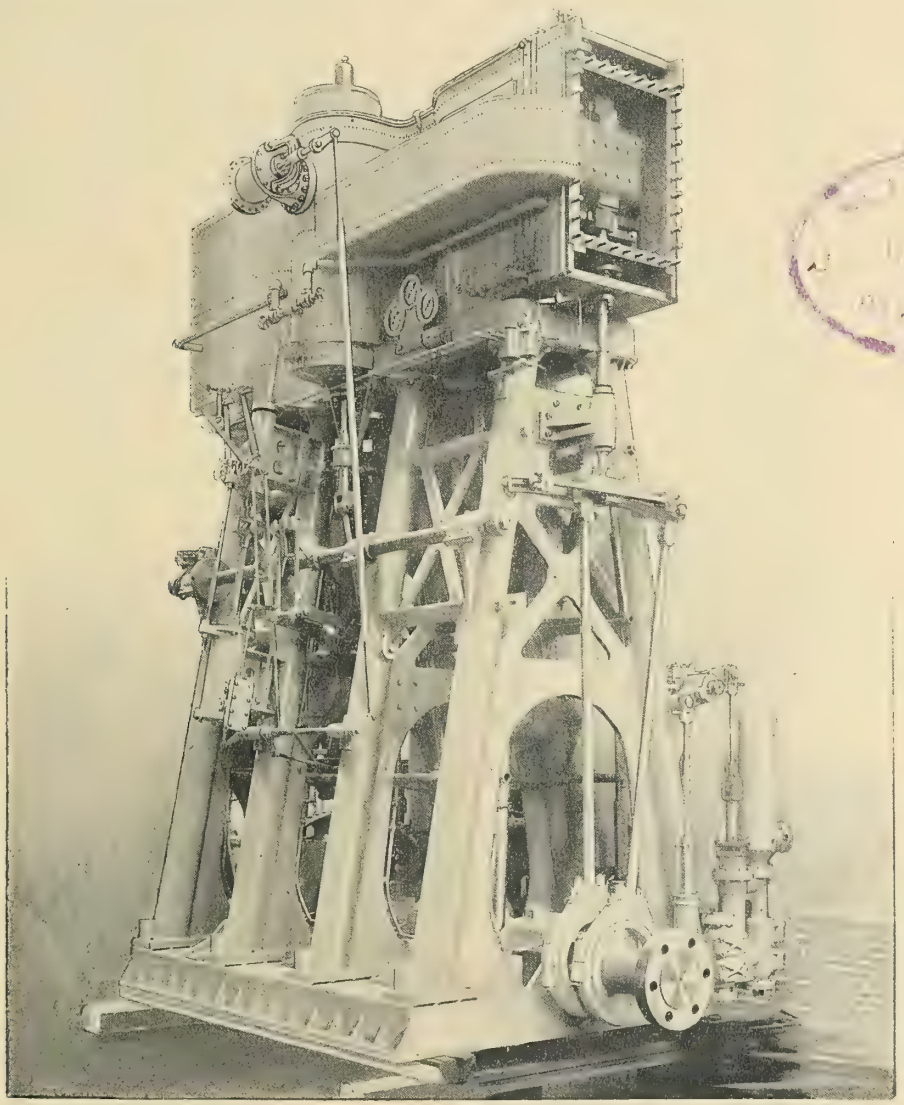
DETAILS OF LARGEST WOODEN STEAMSHIP IN COMMISSION IN THE WORLD.

Although in deep-sea trade steel has superseded wood for steam vessels, there is still a considerable demand for large wooden steamers on the Great Lakes. Perhaps the most interesting of all the wooden cargo vessels engaged in lake traffic is the steamer Thomas Cranage. She is the largest wooden steamship ever constructed on the Great Lakes, and, so far as we know, the largest wooden steamer in commission in the world. In the water she is a neat-looking boat, as will be noticed by reference to the engraving on page 3. She was built in the yard of James Davidson, Bay City, Mich., where many of the



TRIPLE-EXPANSION ENGINE OF LAKE STEAMER THOMAS CRANAGE.

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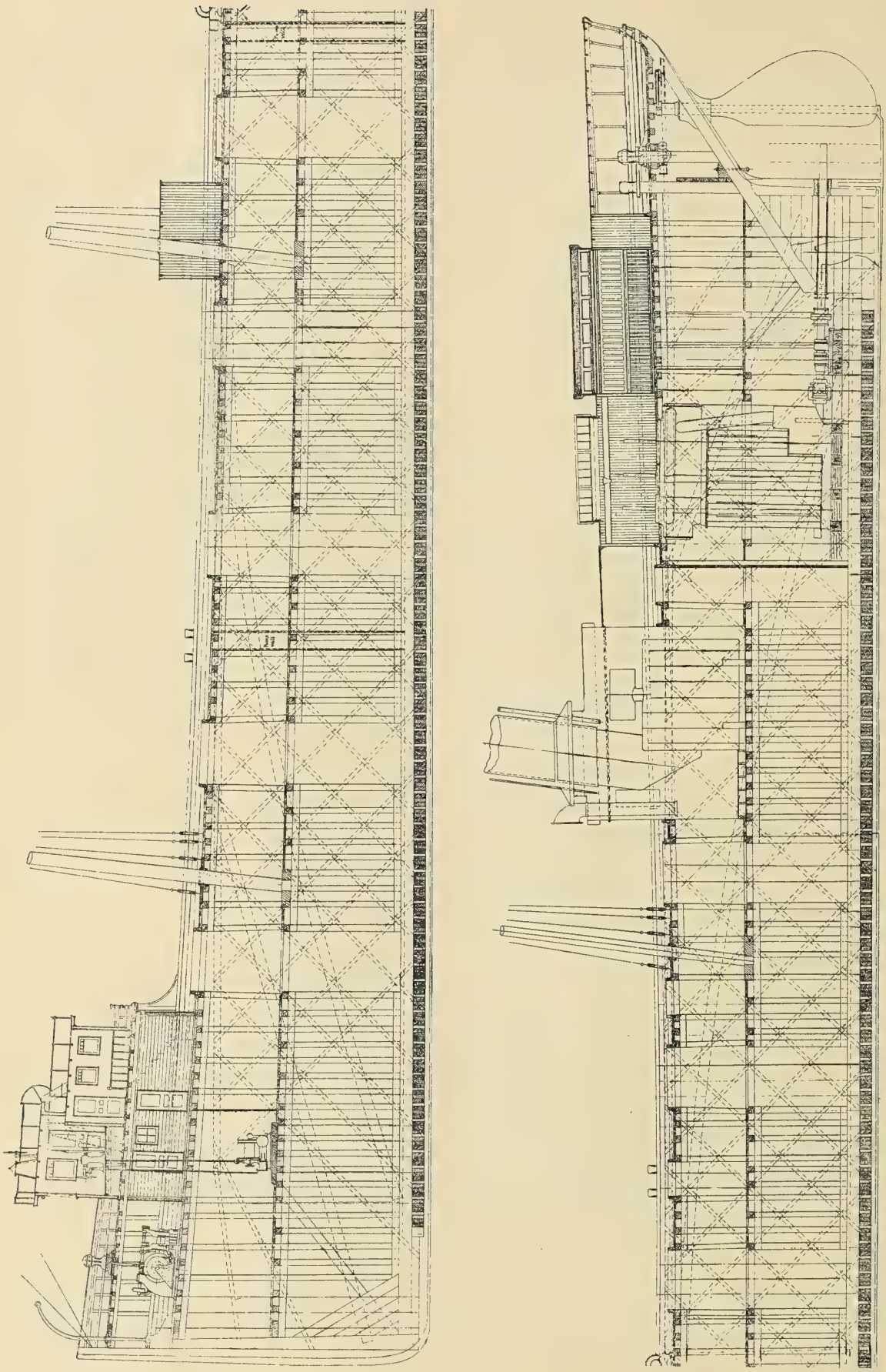
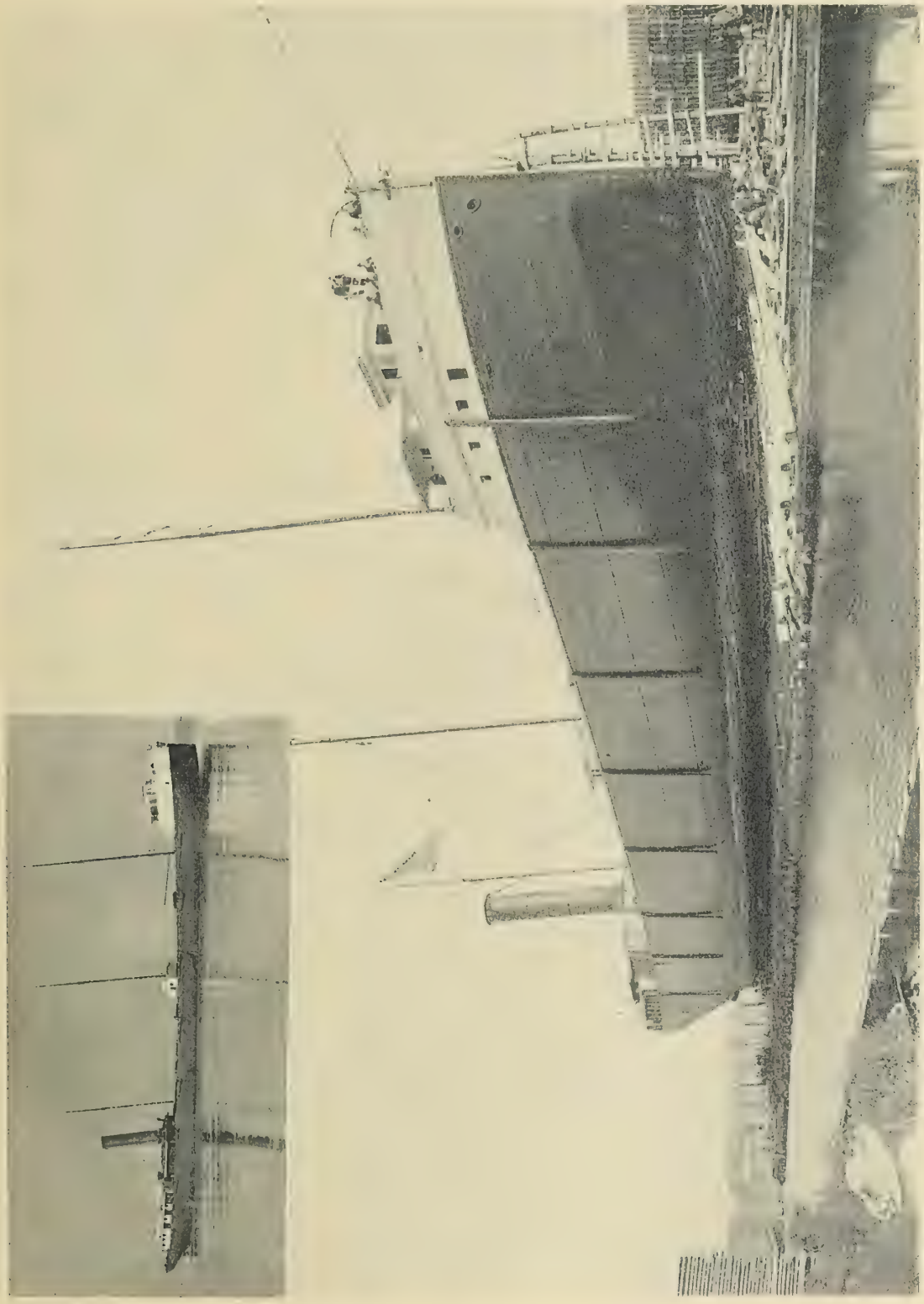


LONGITUDINAL SECTION OF THE WOODEN LAKE STEAMSHIP THOMAS CRANAGE, BUILT BY THOMAS DAVIDSON, BAY CITY, MICH.

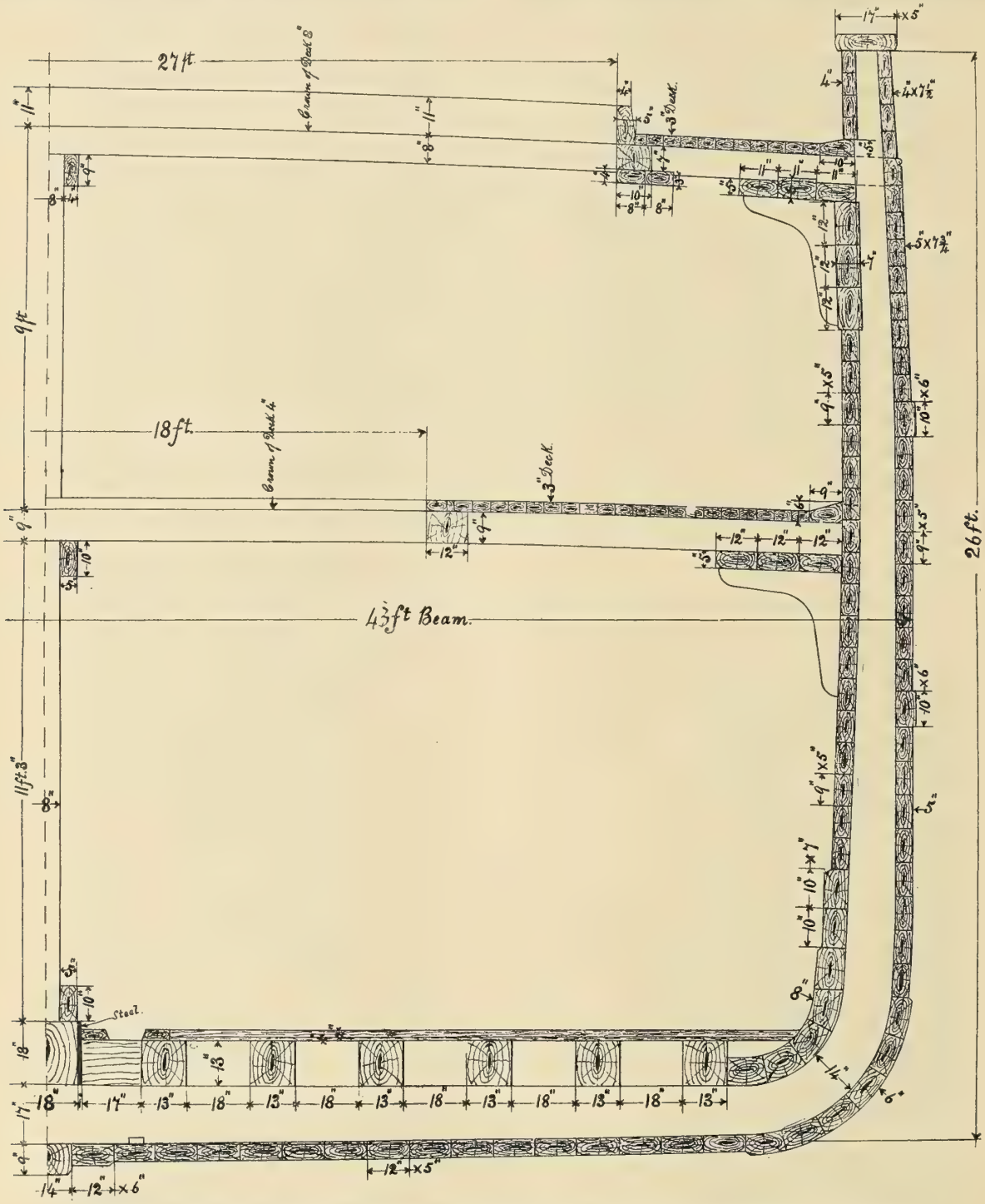
largest wooden vessels on the lakes have been launched. The method of construction can be seen in the sectional drawings, pages 2 and 4.



STEAMSHIP THOMAS CRANAGE AS SHE APPEARED READY FOR LAUNCHING AND AT SEA.

Her extreme length is 330 ft., extreme beam 43 ft., in moulded depth 26 ft., and depth of hold in shoalest place 20 1-2 ft. The frames are moulded from 6 in. flitch, doubled, and on each frame there is an extra floor 6 in. thick, in one piece, running from bilge to bilge. This makes almost an entirely solid bottom. The frames are all spaced 22 in. from center to center, and are moulded 17 in. deep at the throat, 14 in. at the

bilge, and 7 in. at the top. The keel is 14 in. by 9 in. The garboard strakes are 12 by 6. The main kelson is 18 in. by 18 in., and on each side of the main kelson there are fastened steel kelson plates that are riveted together with fish plates, These floor kelsons are 13 in. by 13 in., and run the entire length. On top of the floor kelsons the floor is laid, and this consists of one thickness of 1 in. oak and one thickness of 2 in. oak. The bilge kelsons are 8 in. thick for five strakes



HALF CROSS SECTION OF S.S. THOMAS CRANAGE SHOWING DIMENSIONS OF TIMBERS.

and the steel kelsons are securely bolted to the main kelson. The steel kelson is 18 in. wide and 1 in. thick. There are twelve strakes of floor kelsons, six on each side of the main kelson. and 7 in. thick for two strakes. The ceiling is all 5 in. thick. The lower shelf piece is in three strakes, each strake being 5 in. thick by 12 in. wide. The lower hold stanchions are 8 in. by

8 in. The stringers at the bottom of the stanchions and the stringers at the top of the stanchions are 5 in. by 10 in. The stanchions supporting the upper deck run from the lower hold through the main deck to the upper deck. The clamp strakes are in three strakes, 12 in. by 7 in., and each strake of clamps is notched on to the frame 2 in. The stringers from the rail to the upper deck are 4 in. thick, and these stringers are notched on to the frame 1 1-2 in. The upper shelf piece is in three strakes—two strakes 5 in. by 11 in. and one strake 6 in. by 11 in. The center strake of the upper shelf is notched on to the deck beams 1 in. The upper deck beams are 8 in. by 8 in. and 8 in. by 10 in., and there is a deck beam on every frame. The lower deck beams are 9 in. by 9 in. and 9 in. by 10 in., and they are spaced on every other frame. Under the upper shelf beneath each deck beam, as well as under the lower shelf on each side, is a tamarack ship knee, and these knees are thoroughly bolted to the shelf and deck beams, as well as to the side of the ship. The rail is 17 in. wide by 5 in. thick. The planking on the bottom is 5 in. thick to the turn of the bilge, and around the turn of the bilge the planking is 6 in. thick. From the turn of the bilge to the plank sheer the planking is 5 in. thick. There are also two wale strakes 10 in. wide by 6 in. thick.

The entire construction of the Thomas Cranage is of the best Michigan white oak, with the exception of the deck planking, which is the best Michigan white pine. The deck plank is all 3 in. thick by 5 in. wide. The main kelson is fastened through kelson, frame and keel with five bolts in each frame, each 1 1-8 in. dia. The floor kelsons are all fastened with three bolts in each frame, each 1 in. dia. The bilge kelsons are all fastened with all-through fastening, all bolts being 1 in. dia. The ceiling and planking is all fastened with through fastening, all bolts being 7-8 in. dia. These bolts are driven from the outside through planking, frame and ceiling, and they are fore locked with clinch rings on the inside. The bottom plank is all fastened with 12 in. by 1-2 in. boat spike. The bilge kelsons are all edge bolted with 1 in. irons. The ceiling is all thoroughly edge bolted with 7-8 in. round iron. These bolts in length are driven through two full strakes and into half of the third strake. The outside planking is also thoroughly edge bolted with 7-8 in. round iron, and these edge bolts are driven through two full strakes and into half of the third strake. In addition to the edge bolting of the ceiling and the planking, and in addition to the through bolting of the ceiling and the planking, two spikes are driven in every frame, and of every strake of the ceiling, as well as of the planking.

At the head of the frames for the entire length there is run a steel cord 14 in. by 7-8 in. in dimensions. This cord is let into the frames flush. There is also run a steel arch 14 in. by 3-4 in. from the extreme forward end to under the stern aft. In addition to these, there is a branch running from the cord forward under the fore foot forward, and from the cord aft under the shoe aft. Diagonal straps 5 in. by 1-2 in. are riveted to the cord, also to the arch, and these diagonal straps are 5 in. by 1-2 in., and they run down under the turn of the bilge, and one-third of the way under the bottom. These diagonal straps are also riveted at all of the crossings. On the inside ceiling there is also run a steel arch 14 in. by 3-4 in. from the forward end to the after end. This arch is also securely bolted to the ceiling, and to the frames.

There are nine cargo hatches, each 28 ft. long by 7 ft. wide all spaced 24 ft. centers. Eight of these hatches being forward of the boilers and one being abaft of the boilers. There are also two fueling hatches and bunker capacity for 300 tons of fuel.

The quarters for the officers are all arranged forward. The captain's quarters are in the texas, and these consist of a bedroom, sitting room and office. These quarters are all in the white oak, cabinet finish. The quarters for the firemen and deck hands are in the deck house amidships. The oil and lamp rooms are also in the house amidships. The galley, mess rooms and dining room are located aft, and these rooms are also in white oak, cabinet finish, with decorations in lincrusta walton.

The steam steering gear is a combination hand and steam steerer, by the Globe Iron Works, of Cleveland, Ohio. The steering engine is located on the main deck forward. The steam windlass and steam capstan are also located forward. Both wild cats are fitted for 1 3-4 in. stud linked chain, and the chain lockers are right under the windlass on the main deck forward. The anchors, two in number, each weigh 3,000 lbs. They are Troutman's latest improved. On the quarter deck is the steam capstan, the engine for operating it being located on the bed plate, right under the upper deck. Amidships there is also a steam deck hoister for the purpose of lightering cargo. To the drums of this deck hoister are also attached plungers for the bilge pumps, so that they can be used in case of an emergency.

The steamship Thomas Cranage has two heavy breast hooks and heavy pointers forward. She also has two heavy breast hooks and two heavy pointers aft. The rudder has the stock incased in a 16 in. steel sleeve. The rudder is supported by a rudder supporter, as well as by a heavy iron shoe. The tiller ropes operate on the rudder by means of a quadrant. This ship is supplied with three pole spars, which are stepped in the main deck. There are also two large pump wells running from the upper deck to the floor, which are 5 ft. sq.

The government gross tonnage of the Thomas Cranage is 2,219.52 tons. The net tonnage is

1,855.59 tons. Her capacity is 110,000 bushels of wheat, on an even draft of 16 1-2 feet. She has also carried 3,050 gross tons of iron ore, on a draught of 16 ft., 8 in. Her weight in the water is 4,000 tons.

The motive power consists of a fore and aft triple expansion engine, built by the Dry Dock Engine Works, of Detroit, Mich. The cylinders are 20 in., 33 in., and 54 in., with a stroke of 42 in. The engine is equipped with air pump, condenser, feed, bilge, and circulating pumps, and the cranks are set 120 deg. apart. A universal coupling is fitted between the crank and thrust shafts. The engine is equipped with link motion valve gear and steam reversing gear, with water cylinders. The cylinders and throttle valves are fitted with relief valves. The feed pipes and all the main pipes about engine and boiler are of copper.

The boilers are two in number, also built by the Dry Dock Engine Works. These boilers are each 14 ft. dia. by 12 ft. long, each having three furnaces, and return tubes of 3 1-2 in. dia. The boilers are built of Siemens-Martin steel, of 60,000 lbs. tensile strength, and built to withstand a working pressure of 160 lbs. per sq. in. Under the boilers are placed nine 9 in. I beams, weighing 25 lb. per ft. On top of these beams is placed the ash-pan, running from side to side. To these the boilers are thoroughly fastened. The drain from the ash pan runs to the bilge. The boiler house is built entirely of steel. The tees forming the stanchions are 3 1-2 in. by 3 1-2 in. The plates or panels are 25 in. wide, of No. 10 steel. The roof is made of No. 10 steel, and the panels are fastened by smoke stack rivets to the tees. The syphons are arranged forward and aft, and there is also a Worthington's duplex steam pump, 6 in. by 4 in. by 6 in., with 3 in. suction, for the purpose of filling the tanks, and also washing ship. The feed pump is of the Worthington pattern, 7 in. by 4 in. by 10 in. The boiler is also supplied with Penberthy injector. Speaking tubes connect the engine room with the boiler room, and also the pilot house with the engine room.

The steamship Thomas Cranage is a very fine model, is a handsome ship, and makes at an ordinary gait in ordinary weather thirteen and one-half miles per hour. This is an economical rate of speed, although she has been "crowded" to make fourteen miles per hour. She is classed A1* in the Inland Lloyds Insurance register, and is owned by Thomas Cranage, Major S. P. Cranage, J. W. McGraw, Captain John S. McNeill, H. H Norrington, all of Bay City, Mich.; G. A. Tomlinson, of Duluth, Minn., and Edward Smith, of Buffalo.

An interesting article on the "Development of the Torpedo-Boat Destroyer," by John Platt, who has had much experience in this direction, appears in the May issue of the Engineering Magazine.

MARINE GASOLINE AND GAS ENGINES AS USED IN MODERN MOTOR BOATS.—I.

BY CECIL H. PEABODY, M.E.

The recent developments of various forms of gasoline and oil engines, especially for running launches and small boats, shows that they are meeting the demand for a convenient and safe way of developing power on a small scale. It is believed that a simple statement of the principle of such engines and the difficulties met in their design and construction will be of interest.

All such engines belong to the class of internal combustion engines, since the fuel is burned inside the cylinder of the engine, and the heat generated is applied directly to heating the air that forms the real working substance in the engine. Consequently all gas and oil engines are really hot air engines. The burning of the fuel in the air is merely a very ingenious and effective way of heating the air. After the air has done its work in the cylinder it is thrown out in the exhaust, carrying the heat with it which the engine cannot use and must reject in some way. As compared with a steam engine, the gas engine has two advantages; it does away with the cumbersome boiler, and it allows the use of a wide range of temperature. Here and elsewhere it will be convenient to use the name gas engine for all internal combustion engines, and since in almost all cases the fuel is first gasefied or vaporized before it is introduced into the cylinder the name is proper. If the gas is made from a solid fuel like coal, then the apparatus for making and purifying the gas must be included as part of the plant, whether that be a gas works which makes gas for general consumption or a special apparatus like the Dowson gas generator. The first gas engines used illuminating gas and were employed mainly on account of their convenience, which offset the high price of the fuel used. Large recent gas engines with their own gas generators are now coming into use on account of their economy. Clearly enough, such a cumbersome method of making and using gas is impossible on a boat or for any form of portable engine. The most ready way of making gas is to vaporize some volatile liquid like naphtha or gasoline; consequently the earliest forms of gas engines used for small boats or for motor carriages were merely gas engines which used the vapor of some of the light petroleum products. In England, where legal restrictions interfere with the general handling and use of naphtha and gasoline, much has been done in the line of oil engines, which are constructed to use kerosene oil; but high grade illuminating oil cannot be readily vaporized, and in consequence such engines have difficulties of their own in addition to those common to all gas engines. Two engines have been made thus far which can use heavy oils like petroleum or petroleum refuse, namely the Brayton engine and the Diesel motor; one of these has apparently been abandoned, though it

had some promising features, and the other appears to be at the beginning of a successful career. By far the most experience has been had with gas engines, and the conditions controlling the economical use of internal combustion engines have been discovered in connection with that experience. But since all such engines, with the exception of those using heavy oils, first vaporize or gasefy the fuel before using it and are really gas engines, the conclusion from our experience with the older form can be applied with little or no modification to gasoline and oil engines. This method of dealing with the general problem clears the field and makes it easier to understand the special problems of the later forms of engines.

In order to clearly understand the problems of rapid combustion or explosion, as in the cylinder of a gas engine, it is well to give some attention to the general theory of combustion. Any form of chemical combination which is rapid enough to generate much heat may be considered to be a combustion, but the name is applied usually to rapid oxidation of fuels like wood, coal and gas. The temperature developed by combustion of fuel depends largely on the composition of the fuel, but it depends even more on the rapidity of the combustion and the precaution taken to avoid or to provide for dissipation of heat. The more finely divided the fuel and the more intimately it is mixed with air, the more rapid the combustion will be. Thus forced draft, which draws many fine streams of air through fuel on the grate of a locomotive, gives rise to a high temperature; but on the other hand the walls of the fire box and the tubes rapidly carry away the heat from the fire.

Now the gas and air supplied to a gas engine are thoroughly mixed and are enclosed in a cylinder. When ignited the combustion is so rapid as to cause an explosion, the rise of pressure being due to the heating of the air during the combustion. The explosion, however, is not instantaneous, though the time required is only a small fraction of a second. In much the same way a fluid like kerosene oil may be sprayed in such a way as to be intimately mixed with air and exploded. In oil engines, however, the spraying is so arranged to give at least a partial vaporization. But a solid like coal dust may also be made to give a real explosion. Explosions of air charged with fine flour dust gave rise to a most notable series of disasters only a few years ago.

All internal combustion engines are cooled by water jackets, that is by making the cylinder with double walls through which water can be circulated. These water jackets carry away much heat which is totally wasted, and the only reason for using them is that it is impossible to run an engine with a metallic cylinder unless it is so cooled. As yet no material which can endure a high temperature has been found, which is at all suitable for making engine cylinders. And yet these water jackets have comparatively little effect on the temperatures attained in gas engine cylinders or on the pressures produced in consequence of the explosion.

The temperature realized in the cylinder of a gas engine is limited by the phenomenon of dissociation. For if carbonic acid, which results from the oxidation of carbon in coal, is heated sufficiently it will break up again into carbon and oxygen; in much the same way water or steam may be broken up into its elements, hydrogen and oxygen. Long before the temperature of dissociation is reached in the cylinder of a gas engine, the action which is known by that name begins to affect the combustion, for as the temperature rises the combustion becomes less active and finally ceases, leaving much of the gas unburned. If the pressure of the gas in the cylinder is reduced by expansion, as is the case with all gas engines, the temperature falls at the same time, and the combustion, previously checked by dissociation proceeds, and commonly lasts to the end of the stroke of the piston. The temperature attained by gas exploded in the cylinder of a gas engine is from 2,000° to 3,000° F., depending mainly on the compression experienced by the gas before the explosion. It is a curious feature of the gas engine that the heat yielded by this "after burning" (to translate a German expression) compensates the heat lost to the cold walls of the cylinder, so that the actual expansion curve is something like what would be obtained were there no loss of heat to the walls and no generation of heat after the initial explosion.

Now the efficiency of any heat engine depends on the temperature of the working substance. Just how the efficiency shall be calculated from the temperatures depends on the kind of engine. But even if the problem becomes too complicated to be expressed by a mathematical equation, as is the case for the actual steam engine (taking into account initial condensation and re-evaporation), we know that an increase of the working range of temperature, under proper conditions, gives an increase in efficiency. For example the steam consumption of a steam engine may be reduced by raising the boiler pressure or by using a vacuum. But the temperature of steam rises with the pressure in the boiler, and the exhaust steam is cooler with than without a vacuum.

Coming to the case of the gas engine it appears that the upper temperature, that is the temperature after explosion, is limited by dissociation. If there were no such a thing as dissociation it would be well to use just air enough with the gas to give complete combustion, since in that case we should have the least possible weight of products of combustion, and consequently the heat developed by combustion (which in a gas engine is applied mainly to heating the gases resulting from the combustion), would give the highest possible temperature, and the greatest

efficiency. Unfortunately such an attempt does not give any higher temperature—it only gives more unburned fuel, and consequently more waste. The proper method is to use as much air as possible, so that the heat of combustion being spread through a greater weight of combustion may be better developed before the phenomenon of dissociation intervenes to stop combustion.

This explains why weak mixtures of gas and air are preferred in gas engines. In practice the mixtures are made just as weak as may be, without running danger of missing an explosion, for if the air in excess is beyond a certain fairly definite amount the mixture will not explode. The consequence of all this is that the way of governing a gas engine is to omit an explosion, and this leads to various troubles when gas engines are used for propulsion.

In this connection we may properly consider the gain which has been found from increasing the compression in gas engines before explosion. This gain comes in part from the heating of the gases during compression, so that the heat supplied by the explosion is on the whole supplied at a higher temperature, but the main advantage is due to the greater expansion after explosion which accompanies a greater compression before explosion. This greater expansion gives a better chance for development of heat of combustion by after burning, and also gives a cooler exhaust.

The advantage of using high compression is clearly shown by the following table of tests on Otto engines:

Diameter of cylinder, inches..	9	9.5	7
Stroke, inches.....	18	18	15
Ratio of compression span to piston displacement.....	0.6	0.4	0.34
Pressure of compression above atmosphere.....	38	61.6	87.5
Cubic feet of gas per horse power per hour.....	24	20.5	14.8
Actual efficiency.....	0.17	0.21	0.25
Theoretical efficiency.....	0.33	0.40	0.428
Ratio of efficiencies.....	0.51	0.53	0.58

By the efficiency of a heat engine we mean the ratio of the heat changed into work to the heat supplied to the engine. For the gas engine, the heat supplied is taken to be the heat of combustion of the gas. The heat change into work is determined by dividing the indicated work of the engine by 778, that is by the mechanical equivalent of heat.

The method of making the calculation of efficiency for a given engine test will be instructive and interesting. Dr. Thurston reports that an engine which indicated 9.6 horse power used 24.5 cubic feet of gas per horse power per hour. This gas had a volume of 26.43 cubic feet per pound, and one pound when burned in a calorimeter developed 16,320 thermal units. It therefore appears that one cubic foot would develop

$$16{,}320 \div 26.43 = 617.6$$

thermal units. Consequently the gas used per horse power per hour would develop

$$617.6 \times 24.5 = 15{,}120$$

thermal units. This may be taken as the heat supplied to the engine per horse power per hour. But a horse power is 33,000 foot pounds per minute or,

$$33{,}000 \times 60 = 1{,}980{,}000$$

foot pounds per hour. Since 778 foot pounds are equivalent to one thermal unit, one horse power is equivalent to,

$$1{,}980{,}000 \div 778 = 2{,}545$$

thermal units per hour. Therefore the actual efficiency for this test was,

$$2{,}545 \div 15{,}120 = 0.168$$

which is as good as that of a first class steam engine, not taking account of the losses of heat at the furnace and boiler. This by itself shows why gas engines of small power can compete with steam engines, even when they are handicapped by the high price of gas.

It is interesting to know that Dr. Thurston found further the distribution of heat to be

Work indicated in the cylinder.....	17
Heat carried away by water jacket.....	52
Heat carried away by exhaust gas.....	15.5
Heat lost by conduction and radiation..	15.5
	100.0

This brings out the enormous loss due to the cooling of the cylinder. It looks at first sight as though half the heat might be saved by using some non-conducting material for the cylinder. But since it is not likely that the temperature in the cylinder would be much affected by such a change (for we have seen that it is limited by dissociation) it is at least questionable whether the suppression of the water jacket would lead to a very great gain in economy.

Fig. 1 represents the indicator diagram from an oil engine, which, however, is of the same form as the diagram from a gas engine, or a gasoline engine. The cycle of operations requires four strokes of the piston. From *a* to *b* a charge of gas and air is drawn into the cylinder, the pressure meanwhile falling a little below the atmospheric pressure; from *b* to *c* the charge is compressed, the pressure in this case amounting at the end of the stroke to eighty pounds. At the end of compression the charge is ignited, and an explosion occurs, which is rapid but not instantaneous. After the explosion the pressure in the cylinder was about 240 pounds. The expansion *d e* reduced the pressure to about 40 pounds, and from *e* to *f* the pressure fell nearly to that of the atmosphere.

The deduction of the theoretical efficiency involves the use of some elementary thermodynamic equations, but it is well worth while, as it gives a means of comparing the possibilities of different types of engines, and also gives a standard with which the actual performance can be compared. Thus in the preceding table com-

paring three Otto engines, it appears that the engine with the highest compression gave not only the best absolute efficiency, but also the best relative efficiency when compared with the theoretical efficiency.

For sake of simplicity the diagram of the engine will be assumed to be represented by Fig. 2, which differs in appearance from Fig. 1, be-

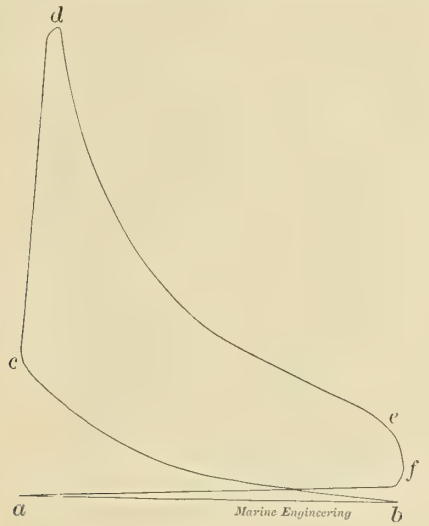


FIG. 1.

cause the explosion *c d* is supposed to be instantaneous and because the release is assumed to be at the end of the stroke. Let it be assumed, further, that the combustion is finished at *d* and that during the expansion from *d* to *e*, and also during the compression from *b* to *c*, no heat passes in or out of the walls of the cylinder. Such curves are known as adiabatic curves, and

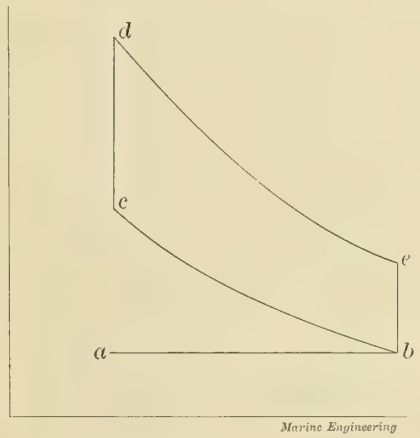


FIG. 2.

for a perfect gas are represented by an equation having the form:

$$p\,v^{1.4} = p_1 v_1^{1.4} \qquad (1)$$

We shall get exactly the same efficiency if we consider that heat is added at constant volume from *c* to *d* and rejected at constant volume from *e* to *b*. The first is of course true, for heat is added during explosion only, according to our previous assumption. But of the heat added, some is changed into work, and the remainder is necessarily rejected. Our new assumption does not change the area of the diagram or the work done, and consequently the heat that would be rejected if the contents of the cylinder were cooled at constant volume till the pressure dropped to that *a b*, must be the same as the heat really thrown out in the exhaust.

Suppose that the temperature of the gas and air at *d* is represented by t_b; then the absolute temperature reckoned from the absolute zero of temperature will be,

$$(T_b = t_b + 460°.)$$

In like manner the absolute temperature at *c*, *d* and *e* will be represented by T_c T_d and T_e.

For convenience let us assume that there is one pound of working substance in the cylinder, then if the specific heat of the gas and air at constant volume is c_v the heat required to raise the temperature from T_c to T_d will be,

$$c_v (T_d - T_c) \qquad (2)$$

And again the heat required to be withdrawn when the air and gas are cooled from *e* to *b* is:

$$c_v (T_e - T_b) \qquad (3)$$

In reality we should consider that the specific heat of the products of combustion differs from that of the mixture of gas and air before explosion, and further we should take cognizance of the changes of volume due to chemical changes; but especially with weak mixtures of gas and air, these considerations have very little importance and may well be neglected.

Now we have already said that the heat rejected is equal to the heat supplied, less the heat changed into work. Conversely, the heat changed into work is equal to the difference between the heat supplied and the heat changed into work. Therefore subtracting the expression (3) from (2) we have for the heat equivalent of the work done,

$$c_v (T_d - T_c) - c_v (T_e - T_b), \qquad (4)$$

and the efficiency, which is obtained by dividing this quantity by the heat applied is:

$$e = \frac{c_v (T_d - T_c) - c_v (T_e - T_b)}{T_d - T_c} = 1 - \frac{T_e - T_b}{T_d - T_c} \qquad (5)$$

But the volume of one pound of perfect gas is directly proportional to the absolute temperature and is inversely proportional to the absolute pressure, that is:

$$\frac{p\,v}{T} = \frac{p_1 v_1}{T_1} \qquad (6)$$

Dividing equation (1),

$$p\,v^{1.4} = p_1 v_1^{1.4}$$

by equation (6) term by term we have:

$$T\,v^{1.4-1} = T_1 v_1^{1.4-1} \qquad (7)$$

or

$$T\,v^{0.4} = T_1 v_1^{0.4} \qquad (8)$$

Applying equation (8) to the diagram represented by Fig. 2 we have:

$$T_d v_d^{0.4} = T_e v_e^{0.4} \quad (9)$$

and

$$T_c v_c^{0.4} = T_b v_b^{0.4} ; \quad (10)$$

but $v_d = v_c$ and $v_e = v_b$, consequently dividing equation (9) by equation (10) term by term we have:

$$\frac{T_d}{T_c} = \frac{T_e}{T_b} \quad (11)$$

$$\therefore \frac{T_d - T_c}{T_c} = \frac{T_e - T_b}{T_b} \quad (12)$$

$$\therefore \frac{T_b}{T_c} = \frac{T_e - T_b}{T_d - T_c} \quad (13)$$

By means of equation (13) we may reduce the expansion for efficiency from (5) to

$$e = 1 - \frac{T_b}{T_c} \quad (14)$$

But equation (10) gives,

$$\frac{T_b}{T_c} = \left(\frac{v_c}{v_b}\right)^{0.4} \quad (15)$$

so that our final expression for efficiency becomes,

$$e = 1 - \left(\frac{v_c}{v_b}\right)^{0.4}$$

The expression for the efficiency indicates just what is shown by the table of results of tests on Otto engines, i.e., that the efficiency is increased by reducing the clearance or explosion space, and thereby increasing the compression before explosion.

Suppose for example the clearance is one-third the piston displacement, so that u_c is one-fourth of u_b; then the efficiency is,

$$e = 1 - \left(\frac{1}{4}\right)^{0.4} = 0.43.$$

This corresponds very nearly to the third case in the table of tests on Otto engines.

When gas engines were first made the pressures realized in the cylinder, and especially the sudden rise of pressure were looked upon as difficulties; now that we are accustomed to using high pressure in steam engines, gas engines and air compressors, and understand both how to provide for such pressures, and the advantages to be attained from them, the tendency has been to continually increase the compression before explosion, and thereby increase the economy of the engine.

New German Transatlantic Liner.

The Vulcan Company, of Stettin, has secured the order for a new Atlantic steamer for the Hamburg-American Company to excel in speed every liner afloat, the trial-trip speed guaranteed being 23 1-2 knots on the measured mile, and 23 knots on the Atlantic, says Engineering, London. The vessel will be between 680 ft. and 690 ft. long over all; but the new White Star liner Oceanic, now building, is 704 ft. over all. The North German Lloyd ship "Kaiser Wilhelm der Grosse," is 625 ft., and her consort, "Kaiser Friedrich," 580 ft. The "Campania" and "Lucania" are 622 ft. long. The breadth, however, will not be much greater than these ships, being 66 ft. 6 in.; while the "Kaiser Wilhelm der Grosse," although over 60 ft. less in length is only 6 in. less in beam. The new ship is therefore exceptionally long for her breadth. The twin-screw engines, which are to develop a collective horse power of 36,000 indicated, are to be of the quadruple-expansion type. The two low pressure cylinders will drive the second and third cranks, the forward and after crank being actuated by tandem cylinders. This arrangement, it is believed, will give the best balancing arrangement, and the least twisting strain on the crankshaft. The boiler installation will not differ materially from that in the "Kaiser Wilhelm der Grosse," which was built by the same firm at Stettin, but for the competing company, the North German Lloyd. There are in her twelve double-ended and two single-ended boilers; but the boilers in the new ship will be worked with Howden's or Ellis & Eaves' draft.

Spanish Battleship "Pelayo."

The "Pelayo" is the only battleship possessed by Spain, and certainly a very formidable vessel, all the more so because she has just received a new and powerful armament at La Seyne, where she was also fitted with new machinery, says the *Navy and Army*, London, to which we are indebted for the excellent view of the vessel and also this description. Upon a displacement of 9,900 tons she has her main armament disposed on the French system—a system, by the way, now apparently abandoned.

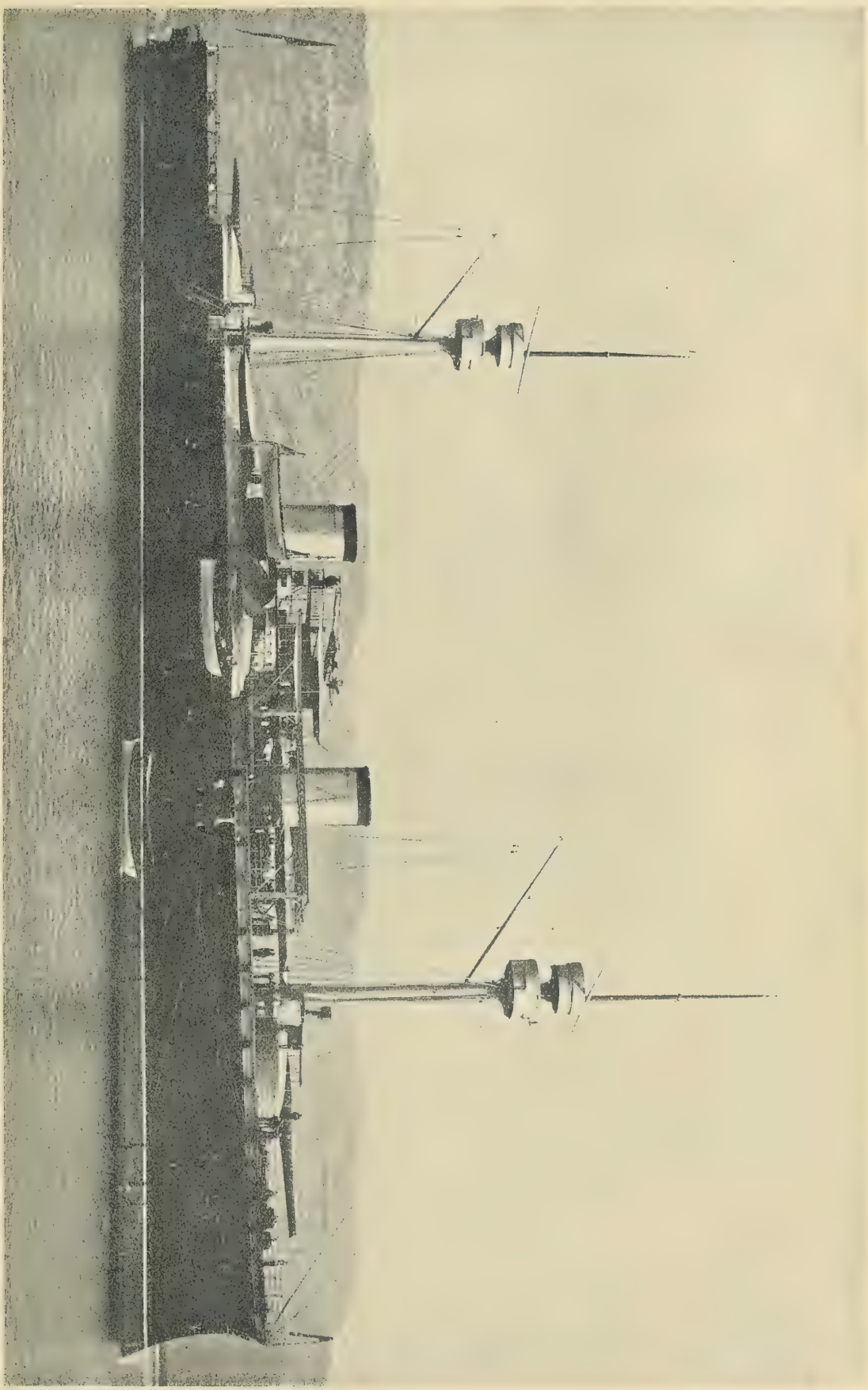
The four heavy guns are disposed singly in barbettes, of which one is forward, the second aft, and the others sponsoned on each broadside.

The advantage claimed for this arrangement is that of not putting too many eggs in one basket, in case a turret should chance to be disabled.

When the ship was built, she was armed with 12.5 in. Hontoria guns in the principal turrets, and 11 in. guns in the others. This arrangement has been changed, and she is now fitted with the new Canet 9.4 in. 22 ton gun, which will perforate 30 in. of steel at the muzzle, and which is much more powerful than the heavier predecessor.

The ship also mounts a very large quick-firing armament, and is protected by a complete compound belt, with a maximum thickness of 17.7 in., a 3.5 in. deck, 15.7 in. bulkheads, and 11.8 in. of steel on the barbettes.

[We understand that the new quick-firing armament consists of nine 5.5 in. rapid-fire guns. The "Pelayo" is 330 ft. long; 66 ft. beam, and has a draught of nearly 25 ft. She is fitted with torpedo tubes. With natural draught she developed 6,800 I. H. P. and a speed of 14 knots, and with forced draught 9,400 I. H. P. and 16 knots. Her coal capacity is about 800 tons, which would carry her about 5,000 miles at 12 knots speed.—Ed.]



SPAIN'S ONLY BATTLESHIP THE "PELAYO."—HEAVILY ARMORED AND POWERFULLY ARMED WITH HIGH-POWER GUNS.

(Photograph by M. Bar, Copyrighted by George Newnes, Ltd., London.)

NOVEL TYPE OF TOWING STEAMERS AND BARGES FOR SERVICE ON THE YUKON.

Eight new boats for the Yukon are building at the Crescent Ship Yard, Elizabethport, N. J., of which, as is well known, Lewis Nixon is the proprietor. They are for the Empire Transportation Co., to be run in connection with the Pacific coast line of that company, which was described at length in our March issue. The river fleet comprises two steam tugs, two passenger barges, and four freight barges. The boats will operate in two fleets, each consisting of one tug, two freight barges, and one passenger barge.

In the design of these boats full advantage has been taken of experience gained with the light-draught gunboats, Sheikh and Sultan, built in 1897 by Yarrow & Co., of London, for the Egyptian Government, on designs by Sir William White.

The general arrangement of the tugs is shown in the illustration on page 15. Their dimensions are: Length over all, 80 ft.; breadth, 32 ft.; depth, 5 ft. 6 in.; draught, 2 ft. 6 in.

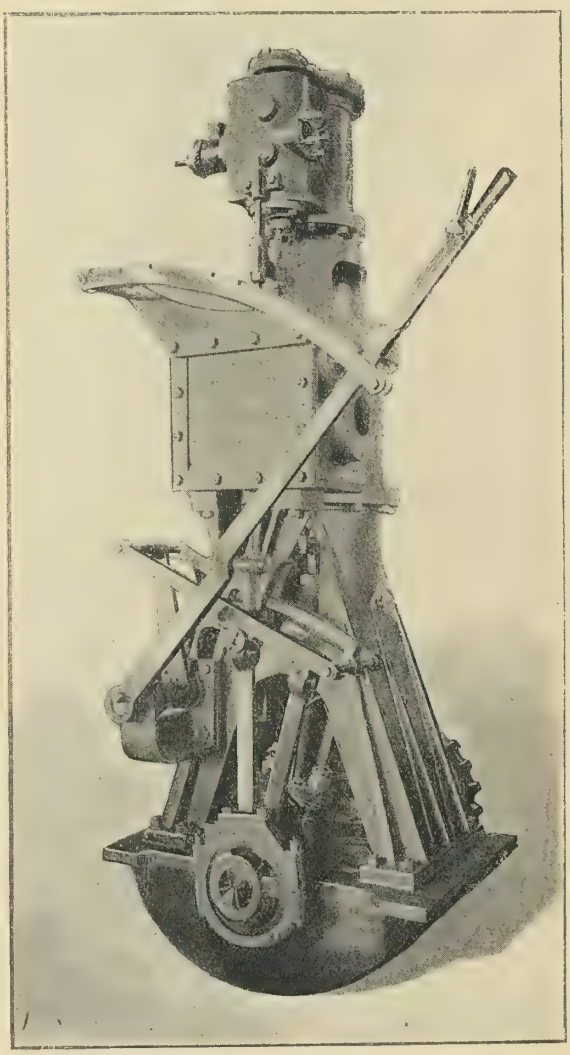
Each tug is composed of eight separate pontoons, which will float separately, and when joined together form one complete molded hull. The very complete midship section, which we publish with this article, gives a correct idea of their construction. The three keelsons shown in the midship section are built up of web framing, the opening shown at the middle of each being closed by a plate, to which the angle irons shown are riveted.

The construction of the two after pontoons calls for special remark. Each tug is to be propelled by six screws. For each of these an entirely independent waterway is worked in the bottom plating of the two after pontoons. The illustration of the general arrangement of the tug shows these tunnels and they can be plainly seen in the photograph on page 13. The frames of the two pontoons, shown in the drawing by broken lines, are worked to the exact section of the tunnels by their planes, except the frame crossing the stern tube. It is arched over the latter. The frames of these two pontoons, therefore, act as girders in stiffening and strengthening the propeller tunnels.

The bow pontoons are built with transom framing similar to that used in the construction of sterns in ordinary merchant practice.

The pontoons are to be tied together by 7-8 in. bolts spaced 6 in. apart all around the angle irons worked on the outside edges of the bulkheads forming the forward and after ends of each pontoon, and by butt-straps bolted outside the hull just below the yellow pine deck stringers shown in the midship section on page 14. These butt-straps are 36 in. wide, 7 ft. long, and 1-4 in. thick. The pontoons can be put together afloat by first filling the bolt holes below the water line with wooden plugs, and then replacing them, one by one, by the bolts.

The machinery equipment of each tug will include three Roberts safety water-tube boilers of 335 H. P. each, carrying steam of 200 lbs pressure. The engines will take full boiler pressure, there being no reducing valves. The combined grate surface of the three boilers will be 100 sq. ft., and the heating surface about 3,000 sq. ft. Each tug has room for 60 tons of coal in her bunkers, and the first barge of each tow will carry 200 tons more. The tug can be coaled directly from the barge through chutes. The ordinary water of the Yukon river cannot be used for boiler feed, being too full of clay and silt. A surface condenser will be used, but some feed makeup will, of course, be required, so fresh water will be carried in one pontoon of each tug. The streams emptying into the Yukon all along the route of these vessels are clear, so for some distance directly below their mouths the feed reserve can be replenished from the river. To enable the boilers to burn wood as well as coal the boiler casings are made of two layers of



TYPE OF ENGINE FOR YUKON BOATS.

asbestos board with an air space between, and the bottom row of tubes is raised higher above the grates than usual.

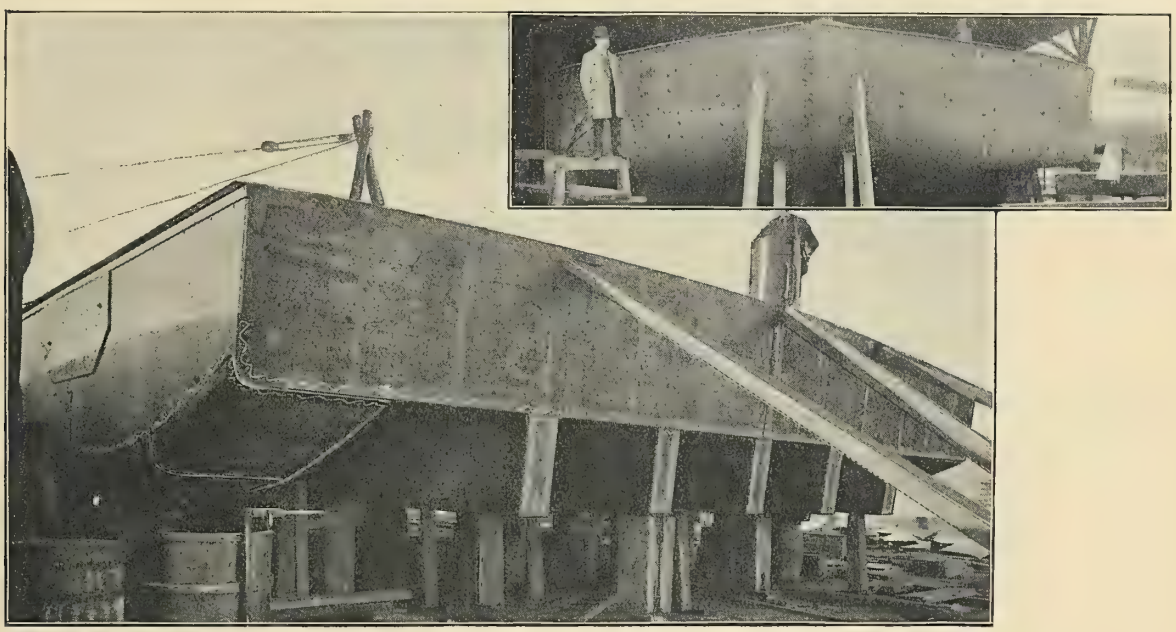
The drawing of the general arrangement of the tug shows the arrangement and location of the engines.

Each screw is driven by a separate engine of 167 I. H. P. Each engine is a vertical, compound, tandem, with the H. P. cylinder on top. The main deck comes about the middle of the L. P. cylinder. The dimensions are: H. P., 8 in.; L. P., 17 in.; stroke, 10 in. Each rests on a bed plate fastened to special keelsons, worked for the purpose. The general appearance of the engines is shown in the engravings on page 12. The H. P. cylinder has a piston valve, and the L. P. a slide valve. The cylinders are unjacketed. Each engine has a double bar Stephenson link and hand reversing lever, which is operated from the main deck. All six engines exhaust into the in thirty days. Both requirements were fulfilled.

Notwithstanding the high steam pressure used, compound engines were adopted instead of triple-expansion, partly because of lower first cost and shorter time needed for construction, but principally because of their greater simplicity and fewer working parts and consequent fewer repairs and greater ease of making the same.

The propeller shafts have brass sleeves shrunk on and secured by set screws, to form the rubbing surfaces in the stern tube and strut bearings. According to the usual fresh-water practice the propeller shafts will have no protection outside the bearings except paint.

Each stern tube has a canted flange cast on it, which bolts to the inclined forward surface of its propeller tunnel inside. The removal of the stern tube stuffing box gives access to the stern tube bearing, which is made in longitudinal halves to facilitate removal. The tugs can be trimmed by



PHOTOGRAPHS SHOWING BOW AND STERN OF YUKON RIVER BOATS.

top of one surface condenser, set against the forward engine-room bulkhead below the main deck. The cylinders are of cast iron, and the piston rods, eccentrics, crank shafts and motions are of cast steel, furnished by the American Steel Co., Thurlow, Pa. The cross heads are of phosphor bronze. The shaft couplings are of cast iron, shrunk on and secured by keys. Each crank shaft has on it three thrust collars abaft the cranks, and the coupling at its after end is enlarged into a jacking wheel. The engines jack by hand. In addition to the twelve engines for service there are two complete spares. All parts of all fourteen engines are interchangeable. The engines were designed and built by Samuel S. Moore & Sons Co., Elizabethport, N. J. The order for the engines required all fourteen to be complete in sixty days, and one to be complete the head sufficiently to allow any stern tube bearing to be shifted while afloat.

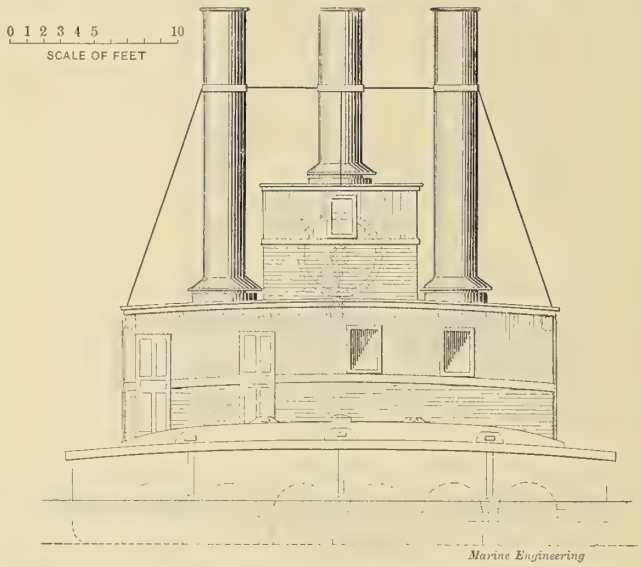
The propeller strut bearing is also made in longitudinal halves for easy removal. The struts will be merely bolted, instead of riveted, to the roofs of the tunnels for convenience in removal.

The propellers are 40 in. dia., of cast iron, with the hub and blades on one piece. There are four blades of large area, the projected area being about 50 per cent. of the circle swept by the tips of the blades less the projected area of the hub. Each blade is nearly a trapezoid, with the longer of the parallel sides at the periphery. The edges of each screw tunnel are well below the water line, so that each tunnel forms an air tight compartment hermetically sealed by the outside water. The action of the screw gradually pumps the air out of the tunnel, and the atmospheric

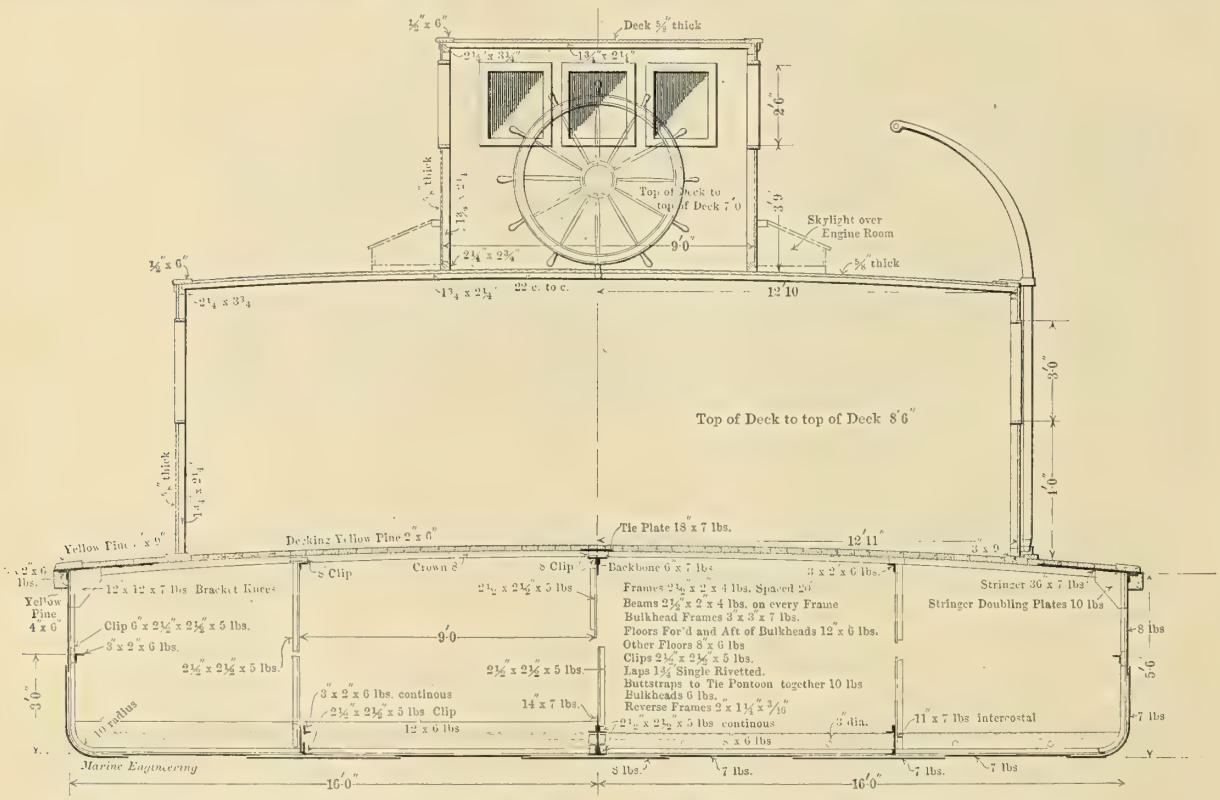
pressure at the same time raises the water in it, until the tunnel is finally full and the screw works in solid water, notwithstanding that under normal conditions it projects one foot above the water line. The propellers will have about the ordinary efficiency in spite of the great friction created by the walls of the tunnel, because the centrifugal loss will be largely done away with by confining the propeller race in the tunnel. With the "Sheikh" and the "Sultan," which were 145 ft. long, and 24 ft. 6 in. beam, Yarrow & Co., on a trial at a draught of 1 ft., 11 1-2 in. obtained a speed of a trifle over thirteen miles an hour with twin screws more than half above the water line and working on this principle.

Mr. Nixon estimates the speed of his Yukon boats as twelve miles an hour for the tug alone, and nine miles an hour for the tug and tow. The tips of the propeller blades run 2 in. above the bottom of the hull, and above the propellers are entirely enclosed by the hull, so that there is little risk of injury to them, but twenty-four spare ones are provided for the two tugs. Each tunnel has a manhole right on top, closed by a cast plate of section so arched that it forms a perfectly fair surface with the interior walls of the tunnel. When this plate is removed, the water in the tunnel falls to the level outside, and the tug while afloat can be trimmed enough by the head to allow work to be done to any screw, strut, or strut bearing, even to the extent of removing it and putting in a new one.

In the "Sheikh" and the "Sultan" this system of propulsion was adopted because of the military advantages which it offered, especially in that it permitted the propelling machinery and its attendants to be more sheltered than they could be with paddle wheel machinery. In these Yukon boats it was adopted principally in order to save weight. Their engines will run at from 200 to 225 revolutions per minute, as against



END ELEVATION SHOWING TUNNELS FOR THE SIX PROPELLERS.

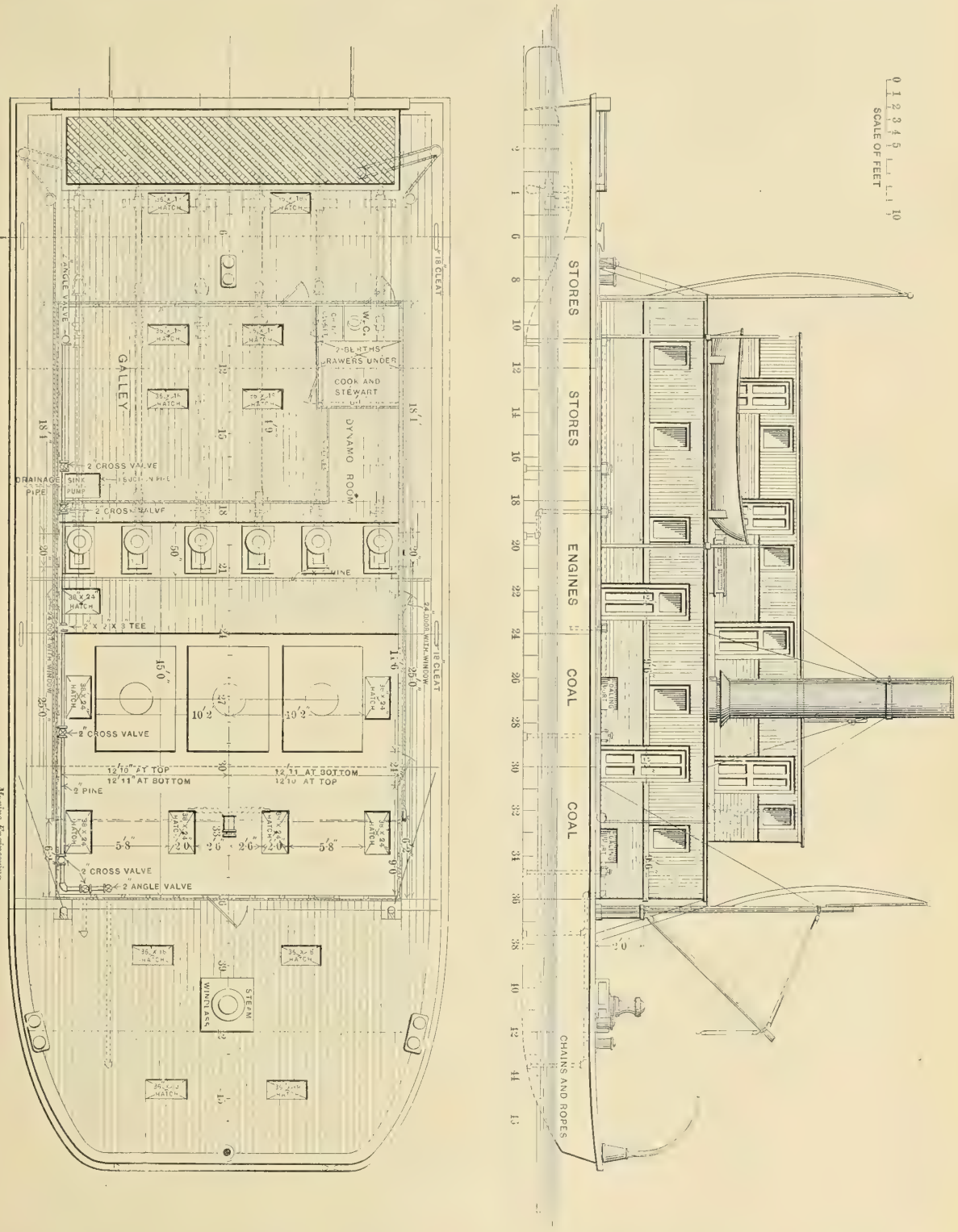

Deck 5/8" thick
Top of Deck to top of Deck 7'0
Skylight over Engine Room
22 c. to c.
12'10
Top of Deck to top of Deck 8'6"
Tie Plate 18" x 7 lbs.
12'11"
Yellow Pine 4 x 6
Decking Yellow Pine 2" x 6"
8 Clip
Crown 8
Backbone 6 x 7 lbs
12 x 12 x 7 lbs Bracket Knees
Clip 6" x 2½" x 2½" x 5 lbs.
3" x 2" x 6 lbs.
2½" x 2½" x 5 lbs.
9'0
3" x 2" x 6 lbs. continous
2½" x 2½" x 5 lbs Clip
12 x 6 lbs
14" x 7 lbs.
Frames 2½" x 2" x 4 lbs. Spaced 20"
Beams 2½" x 2" x 4 lbs. on every Frame
Bulkhead Frames 3" x 3" x 7 lbs.
Floors For'd and Aft of Bulkheads 12" x 6 lbs.
Other Floors 8" x 6 lbs
Clips 2½" x 2½" x 5 lbs.
Laps 1¾" Single Rivetted.
Buttstraps to Tie Pontoon together 10 lbs
Bulkheads 6 lbs.
Reverse Frames 2" x 1¼" x 3/16"
2½" x 2½" x 5 lbs continous
Stringer 36" x 7 lbs
Stringer Doubling Plates 10 lbs
11" x 7 lbs Intercostal
Marine Engineering
16'0"
16'0"
8 lbs.
7 lbs.
7 lbs.
7 lbs

SECTION SHOWING FLOORS FOR'D AND AFT OF BULKHEADS SECTION SHOWING INTERMEDIATE FRAMES

MIDSHIP SECTION OF YUKON RIVER TOWBOAT SHOWING METHOD OF CONSTRUCTION.

about 40 revolutions with a stern wheel. By using a compound stern wheel engine a fair economy would be obtained, but it is expected with these engines to do even better. This, combined with the great saving of engine weight, will enable enough coal to be carried for the round trip, so that these fleets will be relieved of the necessity of tying up during the trip to coal ship. Besides there is much greater security against break-down, as the complete wrecking of an engine would disable only one-sixth of the power. This system of propulsion also offers

GENERAL ARRANGEMENT OF YUKON TUGS BUILT BY LEWIS NIXON, CRESCENT SHIPYARD, ELIZABETHPORT, N. J.



great advantages in handling. With the "Sheikh" and the "Sultan" it was found that from full speed ahead they could be brought to rest in about two lengths. Such quickness is of the utmost value in navigating shallow rivers, the beds of which are continually changing, especially in lonely waters like the Yukon where a vessel aground would find it difficult to get assistance.

Each tug will be provided with one centrifugal circulating pump, a Worthington independent vertical twin-cylinder air pump, and vertical Admiralty feed pumps. There will also be a full outfit of fire and bilge pumps, one powerful steam capstan, and two cargo derricks, to each tug. Each tug will also have an electric light plant consisting of one General Electric direct-connected lighting set, supplying current to sixty lamps and one search light. The voltage will be 110. The search lights are building by the Philadelphia Electro-Dynamic Co.

The first two barges of the tow will be for freight, and the last one for passengers. The dimensions of both freight and passenger barges are: Length, 100 ft.; breadth, 35 ft.; depth, 5 ft. 6 in.; draught, 2 ft. 6 in.; and each barge is made up of ten pontoons. The passenger barges will have fixed berths on the main deck and state rooms on the upper deck. Otherwise their arrangements are well enough shown by their drawings which we publish herewith. Each fleet can carry 800 persons and 2,000 tons of freight.

The Empire Transportation Co.'s steamer Conemaugh is now on her way around to the Yukon. She will be anchored three or four miles out at St. Michael's as a repair ship for the line. She will have complete machine and blacksmith shops capable of handling as large work as will be necessary.

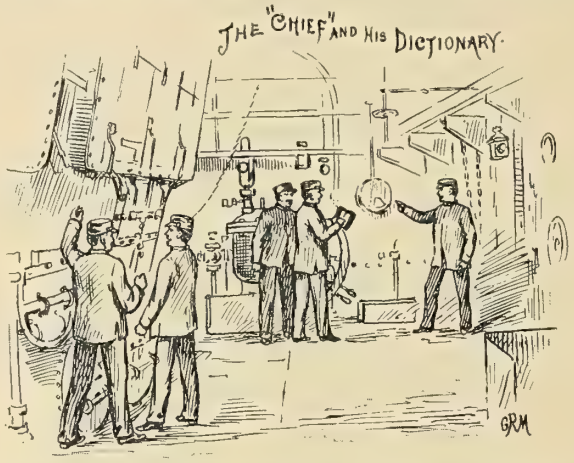
One tug will be completed and put into the water here, and will have a trial trip. The machinery will then be removed, and the cabins and pontoons taken apart. The two passenger barges were shipped April 4, two more barges followed about April 18, and the entire fleet was on the way early in May. The cabins are built in sections and assembled at the yard. The cabin sections, pontoons, and machinery will be shipped by rail to Seattle and thence by steamer to St. Michael's. Sea going vessels there must anchor at least a mile and a half out, and the system of construction adopted allows the pontoons to be simply lowered overboard, floated into place, and bolted together, without going to the great expense and loss of time of taking them ashore, erecting them on ways, riveting together, and launching.

The construction of the vessels was under the inspection of Captain Peter Bloomsburg, of H. Bloomsburg & Co.

The first trip on the Yukon will be made as soon as the ice gets out, probably about June 20. This will be a link in a direct line from Europe to the Klondike.

FIRST AND LAST CRUISE OF THE UNITED STATES CRUISER AMAZONAS.

A short time previous to the outbreak of the present war with Spain the U. S. S. San Francisco was ordered to proceed with the utmost despatch from Lisbon, Portugal, to Gravesend, England, to place a crew on the cruiser "Amazonas" recently purchased by the United States from the Brazilian Government.



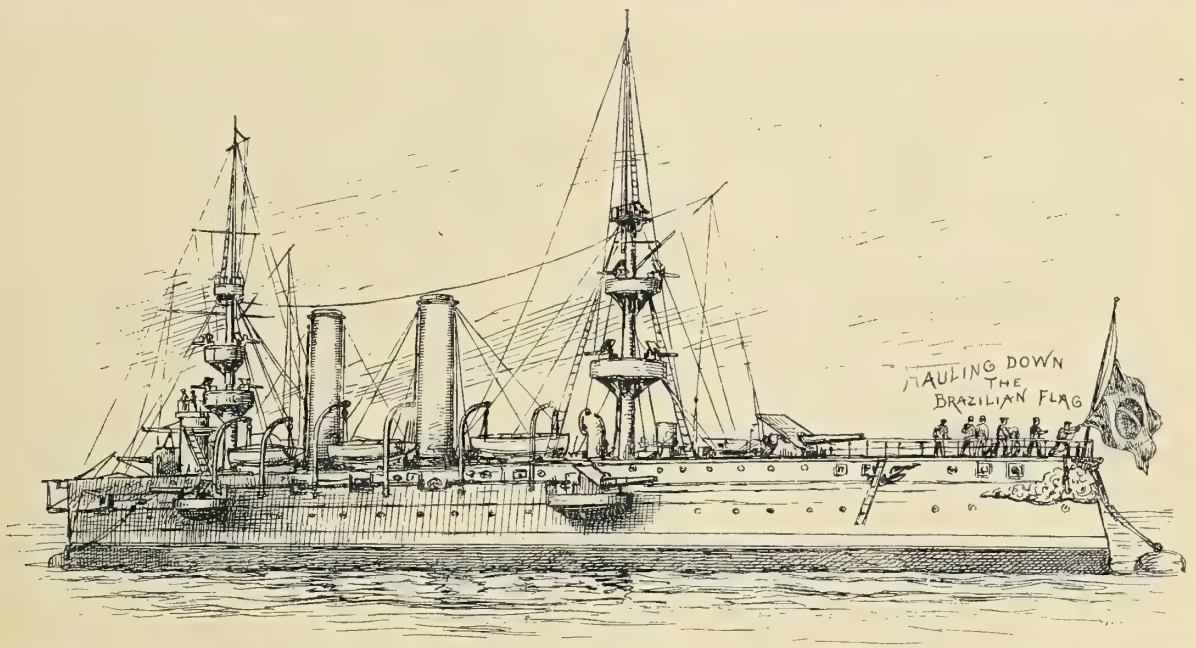
On arrival we found the Stars and Stripes already floating over the cruiser, she having been placed in commission by Lieutenant J. C. Colwell, Naval Attaché at London that same forenoon.

The transfer of a man-of-war from the flag of one nation to that of another in the port of a third power is a very unusual proceeding, though here it was marked with but little ceremony.

THE "MAJOR" KEEPS WARM.

The Brazilian crew was mustered aft on the quarter deck. Briefly the commanding officer expressed his regret at losing his ship for which he had waited *so many years*. This sad duty, he said, became a pleasure, for by this act his government was able to show its friendship to a power which recently had so signally shown its friendship to his country.

The Green and Yellow ensign was then hauled down and in its place was hoisted the Red, White and Blue, and eight officers and ninety-five enlisted men were transferred from the "San Francisco" to the new ship. Placing a ship in commission under the best of circumstances is no sinecure, and in this one felt like a cat in a strange garret. A hasty tour around the ship showed that the names of the various compartments and all instructions on signal gear were in Portuguese, and everything was locked and the keys bunched promiscuously on the cabin table. There was an immediate council of war at which the executive officer presided, and with the aid of certain plans, and the Portuguese dictionary of the Chief Engineer, a successful attack was made upon the ship's compartments. This was none too soon, for already Jack, forward, had formed a boarding party and knocked in the head of a stout puncheon of liquor left behind by the



Brazilian sailors in their retreat. This was speedily carried aft and subsequently it proved to have wonderful thermal properties. Like most British cruisers no means of heating the living spaces had been provided, and on deck we were exposed to real Lunnon weather, drizzle and sleet by day and frost by night, and between decks everything was kept damp by the condensation of moisture on the steel of the ship. The only way to keep warm during the day was to keep moving, especially as we were accustomed to the fine weather of the Riviera. At dinner we gathered around the tables in regulation overcoats, with collars, and, out of respect to our surroundings, trousers turned up. It was at night, however, that the bravery of our fellows was shown, for it required rare courage to plunge into the cold beds and rarer still to turn out. "El Medico," as the Portuguese label styled him, saved lives and earned the good will of his messmates by discovering that a portable electric lamp was as good as a hot water bottle. The "Major," who had two lamps, was considered the luckiest man aboard, as he enjoyed the unusual sensation of heat penetrating the soles of his feet and creeping up his spinal column at the same time. A requisition was made on the Paymaster for two of the largest stoves in all England, and visions of huge crackling logs filled our minds. When the stoves appeared, our executive swore they were only drummers' samples, as they bore about the same proportion to an old fashioned base burner as the British Isles do to the United States. While they were being set up our Chief Engineer did some rapid figuring on the ratio of grate surface to heating surface, and there was no scarcity of firemen to carry his theory into practice. What the stoves lacked in size was compensated for by the enthusiasm of the stokers, who worked watch and watch at a 30-knot gait all through the voyage. But other troubles were coming. Fresh water got so scarce that we couldn't afford a chaser, and the more the engineers distilled the less there was in sight. Some one suggested that the weight of water distilled was forcing it through the bottom, and an ensign was sent into the bilges to hunt for a hole. Before he crawled out a list to starboard caused an investigation that showed some of the double bottoms were filled with fresh water. How it got there even the Chief Engineer with his invaluable dictionary couldn't tell.

After ten days of constant hard work all the coal and ammunition was on board, and on March 27, with a homeward pennant 170 ft. long, the "Amazonas" followed the motions of the flagship and was soon headed for the western

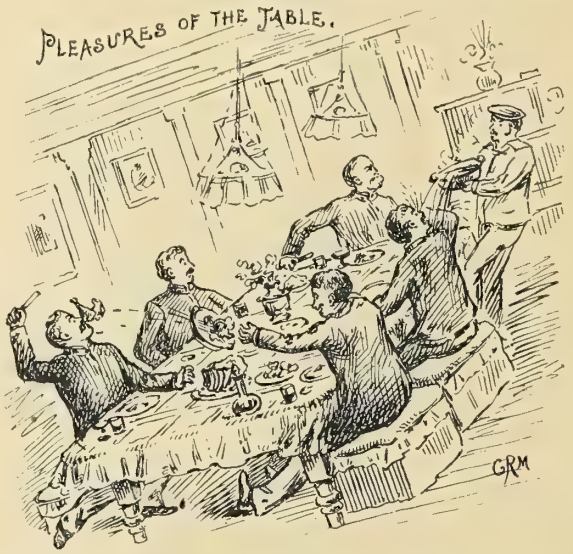
ocean. The first few days out, while passing through the channel, the weather was fine with smooth seas. Running at what was an economical speed for the "San Francisco," about 265 miles a day were logged, and it was calculated that we would reach New York about Easter day. But there are some things not down in the regulations, and on April 4 we ran into a north-

west gale which continued with but slight remissions for a week.

The "Amazonas" has a low freeboard, and with even a moderate sea running, the decks are constantly wet. As the storm increased the seas would sweep down the deck and bring up against the steel bulkhead of the wardroom, which opens on the quarter deck by two sliding steel doors. One evening as our executive stepped in in his oilskins he brought with him a generous portion of the Atlantic, and for a time the ward room was an improved swimming tank, with several amateur divers contesting for the driest spots. An usually heavy roll (26° to port and 40° to starboard) deposited about everything movable, including bureau drawers and contents, ink bottles, and officers of various grades on the deck in one confused heap. It was several days before the Chinese laundry appearance of the wardroom wore off. Meanwhile the gale was increasing and making things pleasant on deck. One tremendous sea came over the forecastle, nearly carried the Captain overboard, stove in and partially carried away the starboard life boat, wrecked the hand steering wheel and expended the last of its strength on the wardroom doors. The starboard one slid open and again there were impromptu aquatic sports. If there was one thing our boat excelled in it was the unexpected in motion, for just where you expected it to be is exactly where it was not. We all took such an interest in these demonstrations that meals were forgotten until exhaustion made eating a necessity if not a pleasure. One gunnery enthusiast took occasion to deliver illustrated discourses on the flight of projectiles whenever we sat down to meals. Toward the end of the voyage provisions ran low and cold corned beef, hardtack, prunes and coffee were made into a wonderful variety of combinations, which though spelled differently tasted alike. All hands were greatly disappointed when on the ninth the flagship signaled to change course and proceed to Halifax, a change of plan necessitated by a shortage of coal on the flagship.

While at sea and cut off from all news of the prospective war we gradually thought and talked less and less about it. But as we approached land our curiosity became more and more excited, and when the pilot and health officer boarded us they were rushed for news of the war. We got a lot of pleasant attention, too, from the good folk of Halifax. The general sentiment was well expressed in the words of a small boy in a boat, who was busy grabbing at the elusive bladder tied to the end of our homeward bound pennant. When hailed he replied: "Lick them Spanish, and while you're about it, lick 'em good—for us."

The run from Halifax to New York gave a chance to clean up and on April 15 we dropped anchor off Tompkinsville. On the eighteenth we went up to the Navy Yard between lines of screeching tugs and ferryboats, and the cruise of the "Amazonas" was finished. Renamed, remanned and partially reconstructed, she is now,



under the name of the "New Orleans," one of the Flying Squadron, and in the fight which now seems so imminent she will undoubtedly prove herself a great acquisition to the United States Navy.

Additional List of Auxiliary Vessels.

We publish this month a list of vessels added to the navy which were not included in the list published in May. Not all the particulars concerning the vessels are obtainable, but the table has been made as complete as possible with proper regard for accuracy. We take occasion to call attention to some changes which should be made in the table published in May. The

WARSHIPS AND AUXILIARY VESSELS RECENTLY ACQUIRED BY THE UNITED STATES NAVY BY PURCHASE, CHARTER OR TRANSFER (*SECOND TABLE*).

Old Name and Date.	Old Class.	Length.	Breadth.	Depth.	Draught.	Displacement. Tons.	Horse Power.	Speed. Knots.	Where Built.	Hailing Port.	Former Owners.	New Class.	New Name.
		ft. in.	ft. in.	ft. in.	ft. in.								
Abarenda, '92	Steel freighter	314	42	26	.. :	2,123 gross	250 N.	8	Newcastle-on-Tyne.	Newcastle.	Graham S. S. Co.	Collier	Abarenda
Active, '88	Tug	100	22 6	12 6	.....	174 "	500	.....	San Francisco.	San Francisco.	J. D. Spreckels & Bros. Co.	Tug	Active
Aileen, '96	Yacht	140	20	15	8 9	151 net	.....	16	John Roach.	New York.	Richard Stevens.	Aux. gunboat	Aileen
Albatross, '82	Fish steamer	200	27 6	16 9	12	639 gross	289	9	Wilmington.	.....	U. S. Fish Commission.	Gunboat	Albatross
Algonquin, '98	U. S. Rev. cutter	205	32	17	11 6	906	2,500	18	Globe Iron Works.	Great Lakes.	U. S. R. C. S.	Aux. gunboat	Accomac
Celtic King, '91	Steel meat and cargo steamship	371 8	42 2	27 2	.....	3,738 gross	360 N	12	Workman, Clark & Co. Belfast.	London.	Federal S. N. Co.	Supply ship	Celtic
C. G. Coyle	Iron tug	91 4	21	10 3	.....	152 "	.....	.....	.....	.....	.....	.....	Choctaw
Chatham, '84	Coast liner	270	42	34	.....	2,729 "	1,800	.....	Philadelphia.	Baltimore.	Merchants' & Miners' T. Co.	Repair ship	Vulcan
Corsair, '91	Steam yacht	204	27	16 5	13	560 "	1,900	18	Neafie & Levy.	New York.	J. P. Morgan.	Aux. gunboat	Gloucester
C. P. Patterson, '83	Survey steamer	175	27 3	.....	14 2	718	350	9	Brooklyn, N. Y.	Pacific Coast.	U. S. Coast Survey.	.....	Patterson
Enterprise, '90	Tug	91 6	21	10	.....	124 gross	.....	.....	Camden, N. J.	.....	Hy. Brown.	Tug	Modoc
Fearless, '92	Steel tug	145	26	16	.....	400 "	1,200	.....	San Francisco.	San Francisco.	J. D. Spreckels & Bros. Co.	Tug	Iroquois
Felicia, '98	Steam yacht	142	20	11	6	.....	1,200	17	J. M Robins Co.	New York.	E. W. Bliss.	Aux. gunboat	Uncanoomuck
Fish Hawk, '79	Fish steamer	146 6	27	10 9	8 6	442 gross	.....	9	Wilmington, Del.	Wilmington.	U. S. Fish Commission.	Gunboat	Fish Hawk
Free Lance, '79.	Yacht.	109	20	10	7	90 net	600	16	Lewis Nixon.	New York.	F. A. Schermerhorn.	Aux. gunboat.	Free Lance
Gedney, '75	Survey steamer	140	23 8	10 4	6 9	174 gross	250	8	New York.	.....	U. S. Coast Survey.	.....	Gedney
Gresham, '97	Revenue cutter	205	32	17	11 6	906	2,500	18	Globe Iron Works.	U. S. R. C. S.	U. S. R. C. S.	Aux. gunboat	Gresham
Harlech, '97	Freighter	235 2	34 3	14 3	.....	1,282 gross	160 N.	.....	Sunderland.	London.	J. & C. Harrison.	Collier	Pompey
Hercules, '88	Tug	101 5	20 6	10 8	.....	142 "	.....	14	J. H. Dialogue & Son.	New York.	Standard Oil Co.	Tug	Hercules
Hortense, '93	Steel tug	102	21	9 6	.....	130 "	.....	.....	J. H. Dialogue & Son.	Galveston.	Galveston Cons. Co.	Tug	"
Illawawa, '96	Steam yacht	106 3	18 6	10 6	8 2	119 "	.....	13	Bath Iron Works.	Boston.	Eugene Tompkins.	Aux. gunboat	Oneida
Illinois, '73	Transatlant liner	343	43	32 1	25	3,126 "	1,200	10.5	Cramp.	New York.	Inter. Nav. Co.	Provision ship	Supply
John Dwight, '96	Steam Lighter	120	27 3	7 9	7	151 "	.....	.....	Roderwald & Co.	.....	.....	Lighter	Pawnee
Justin, '91	Steel freighter	277	39	18 2	.....	2,206 "	200 N.	10	Middlesboro.	London.	Eng. & Amer. Shipping Co.	Collier	Justin
Kingtor, '96	Steel freighter	310	44	20 5	.....	2 738 "	250 N.	9	Ropner & Son, St'kt'n.	London	J. Holman & Son.	Collier	Caesar
Louis McLane, '65	Side-wh'l rev. cut	163	28	11 2	6	315	410	10.5	Transf. from Navy '65.	Key West.	U. S. R. C. S.	Pilot & Scout	L. McLane
McArthur, '76	Survey steamer	115	20	.....	12	130 "	.....	.....	Mare Island, Cal.	Pacific Coast.	U. S. Coast Survey.	.....	McArthur
*Menemsha, '85	Freighter	304 3	38 8	26 5	.....	2,716 "	220 N.	.....	Newcastle-on-Tyne.	New York.	T. Hogan & Son.	Water ship	Iris
New York, '89	Transatlant. liner	560	63 2	39 2	23	13,300	20,000	21.8	Clydebank, Scotland.	New York.	Inter Nav. Co.	Aux. cruiser	Harvard
Paris, '88	Transatlant liner	560	63 2	39 2	23	13,300	20,000	21	Clydebank, Scotland.	New York.	In er. Nav. Co.	Aux. cruiser	Yale
Penelope, '93	Steel yacht	218	27	16	.....	541 gross	750	14	Leith, Scotland.	Boston.	H. E. Converse.	Aux. gunboat	Yankton
Pennwood, '92	Iron tug	101 8	21 8	11 3	.....	156 "	.....	.....	Sparrows Point, Md.	.....	J. R. Ford Trans. Co.	Tug	Powhatan
Philadelphia, '96	Pilot boat	140 8	25	14 6	12	300 "	700	15	Neafie & Levy.	Philadelphia.	Philadelphia Pilots.	Miscellaneous	Peoria
Restless, '87	Yacht	104	16	8 8	.....	104	55)	12	Houston & Woodbridge	Philadelphia.	H. W. Sibley.	Aux. gunboat	Restless
Right Arm, '91	Tug	124 4	27	10 5	.....	238 gross	.....	.....	Athens, N. Y.	New York.	.....	Tug	Pontiac
Southery, '89	Freighter	288	38 8	18 3	.....	2,068 "	1,000	9	Sunderland.	St. John.	T. E. Morrison.	Collier	Southery
Thespia, '95	Steam yacht	169	23 3	13	9 10	312 "	600	12	Cramp.	New York.	David Dows, Jr.	Aux. gunboat	Hist
T. P. Fowler, '83	Tug	97 6	24	11	.....	161 "	.....	.....	Newburg, N. Y.	Albany, N. Y.	.....	Water boat	Mohawk
Venezuela, '89	W. I. liner	303 6	40 2	27 9	19 6	2 843 "	2,500	15	Cramp.	Wilmington, Del.	Red D. Line.	Aux. cruiser	Panther
Vigilant, '83	Tug	107	21	12 8	.....	177 "	280	.....	Philadelphia.	San Francisco.	J. D. Spreckels & Bro. Co.	Tug	Vigilant
Viking, '83	Yacht	125 6	20 6	10 4	9	141 "	.....	13	John Roach.	New York.	Horace C. Hutchins.	Aux. gunboat	Viking
W. H. Brown, '97	Tug	156 8	28	17	13	833 "	2,000	17	F. W. Wheeler & Co. West Bay City.	Pittsburgh.	W. H. Brown.	Water boat	Piscataqua
Yorktown, '94	Coast liner	300	40	34	20	2,898 "	3,500	16	John Roach.	New York.	Old Dominion S. S. Co.	Aux. cruiser	Resolute
Yumuri, '89	W. I. liner	336 2	43 2	22 3	18	3,497 "	2,600	14	John Roach.	New York.	J. E. Ward & Co.	Arm'd transp't	Badger

*Formerly British S. S. Dryden.

Italian steam yacht Aegusa has not been acquired by the navy, negotiations for the purchase of this vessel not having been completed before war was declared. Owing to a typographical error the new names of the Morgan liners were not correctly given. These should be "El Rio," now "Dixie;" "El Sol," now "Prairie;" "El Sud," now "Yosemite." The tug Paoli, though examined by the board, was not purchased. Details regarding the armament of the vessels in their new classes cannot be given, as the government, for good and sufficient reasons, has prohibited the publication of such details. A number of vessels has been requisitioned by the War Department for the transport of troops.

ESTIMATED WEIGHTS OF MACHINERY, WITH FORMULAE FOR SCREW AND SIDE-WHEEL STEAMERS.—II.

BY PROF. GEO. R. M'DERMOTT.

Throughout the course of many years' experience in business life, the writer has gathered together the recorded detail weights of machinery of over 300 vessels, embracing almost all of the types to be found in both the warship and mercantile fields of service.

Some time ago I subjected this collection of data to a rigorous analysis with the object of arranging it in a form which would lend itself most readily to estimating purposes. Throughout these investigations, and in the arrangement of the information certain conditions were laid down and kept clearly in view, the chief aim being to devise a system, as little complicated as possible, by which estimates of weight could be made within as short a space of time as would be consistent with the degree of accuracy required in such work; the system to be so arranged as to furnish, at the same time, the weights in such divisions as would be convenient in making trim, strength and stability calculations of the vessels in which the machinery was to be fitted. With this in view, four leading divisons were fixed upon, viz.; (1) Engine-room weights; (2) boiler-room weights; (3) shafting weights; (4) propeller weights. In the first division (engine-room weights) it was found very early in the investigations that it would be necessary to split it up under two heads: Warship engines and mercantile engines, these heads being again subdivided as follows: Warship engines: (a) launches, pinnaces, torpedo-boats, destroyers, and torpedo gunboats; (b) battleships, cruisers, gunboats, and commerce destroyers with horizontal engines; (c) battleships, cruisers, gunboats, and commerce destroyers with vertical engines. Mercantile engines: (d) Launches, and other small boats; (e) steamers of all classes, including yachts; (f) side-wheel engines, oscillating; (g) side-wheel engines, diagonal. The engine-room weights include the main engines (excepting all shafting, bed plates, shaft bearings, caps, bolts, etc.), auxiliary engines, all pumps and connections, condensers, water in condensers and pipes, pipes in engine room, tools, workshop fittings, platforms, gratings, ladders, ventilator fans to engine room, etc. In the case of warships, the weights of steam steering engine and electric light machinery are included also.

The second division (shafting) was separated under two heads: Screw propelling shafting and paddle propelling shafting. The weight of shafting includes crank, line, thrust, and propeller shafts, engine bed plates, shaft bearings throughout, caps, bolts, etc.

The third division (boilers) was divided off under three heads: Main boilers, main boilers water, auxiliary boilers and water, the first two heads being subdivided into the following classes: Scotch boilers, navy or low cylindrical boilers, and locomotive boilers.

Boiler room weights include boilers and mountings, uptakes, smoke stacks, pipes within boiler room, forced or assisted draft arrangements and appliances, ventilating arrangements, ash hoists, stokehold plates, platforms, gratings, ladders, firebars, tools and utensils, all fittings and spare gear, water at working level.

The fourth division (propellers) was divided under two heads: Screw propellers, and side wheels, these heads being subdivided as follows: Screw propellers, detachable, 3 or 4 blades; screw propellers, solid propellers, 3 or 4 blades; side wheels, feathering floats; side wheels, radial floats. The weight of propellers includes weight of boss, blades, bolts and washers. (Cast iron or steel.)

Formulæ for Estimating Weights of Boilers Exclusive of Boiler Room Weights.

Scotch Boilers:	
Single ended	Wt. in tons$=.0075N\ [D^2\ (L+2)+HS]+1.5N.$
Double ended	Wt. in tons$=.0075N\ [D^2\ (L+2)+HS]$
Navy Boilers:	
Single ended	Wt. in tons$=.005N\ [D^2\ (L+2)+HS]+8\ N.$
Double ended	Wt. in tons$=.005N\ [D^2\ (L+2)+HS]+6.5N.$
Locomotive Boilers	Wt. in tons$=.0075N\ [D^2\ (L+2)+HS]-1.5N.$

FORMULÆ FOR ESTIMATING WEIGHTS OF BEAM SIDE WHEEL ENGINES.

Beam Surface Condensing	Wt. in tons$=.55\ (\sqrt{DL}-10)$
Beam Jet Condensing	Wt. in tons$=.64\ (\sqrt{DL}-60)$

The weight of side wheels includes ribs, rings, floats, bolts, etc., complete; in the case of feathering floats, the weight of feathering gear is also included.

The detail weights were carefully collected under the different heads and subdivisions, the totals were then tested, tried, and measured on different bases separately and in combination before the formulæ presented were finally accepted as satisfactory. It is the writer's belief that it would serve no useful purpose to describe the details of the investigations, and he will content himself with presenting the formulæ as finally adopted.

The formulæ are given (February issue page 19), and an example is also given showing the method of application and the work involved in estimating the weight of machinery of the U. S. S. Olympia, see page 21 this issue.

In the writer's opinion the formulæ will give results not more than from 3 per cent to 5 per cent in error, allowing for a normal amount of spare gear. The formulæ have been built up on current practice, triple expansion engines, and boiler pressures from 150 to 175 lbs. It is interesting to note, however, that they give

a close approximation to the weights of compound engines and pressures of 80 to 100 lbs. This, it would seem, points to the fact that, although higher pressures involve greater strength, improvements in materials have followed right along the line of increased pressure, permitting the weight per unit of surface to remain constant.

Unfortunately, sufficient data is not at hand of quadruple expansion engines to allow of definite statements being made as to the probable increase in weight, but in a general way I think that an increase of about 5 per cent should be made on the engine room and boiler room weights as estimated by formulæ.

It is also very difficult to obtain reliable

ESTIMATED WEIGHT OF MACHINERY, U. S. S. OLYMPIA.

Engines.

Type	V. T.
No. of sets	2
Diam. H. P. cyl	49
" I. P. cyl	59
" L. P. cyl	92
Stroke	3.5

Propeller.

No. and diam. 2	14.75
Surface	68
No. of blades	3

Shafting.

	Length.	Diameter. Shaft.	Hole.
Crank	57.76	16	7.5
Thrust	38.88	15.75	7.5
Line	70.00	15.75	7.5
Propeller	78.00	16	7.5

Auxiliary Boiler.

Number	
Diameter	None.
Length	

Main Boilers.

Type	Scotch D. E.	S. E.
Number	4	2
Diameter	15.25	15.25
Length	21.25	10.96
Heating surface (1)	5659.7	2829.9
Tube diameter	2.25	2.25
" length	7.66	7.6
Furnaces, number	8	4
" diameter	3.25	3.25
Height of water	6	6

Engine-Room Weights.

$HP^2 = 42^2 =$ 1764
$IP^2 = 59^2 =$ 3481
$LP^2 = 92^2 =$ 8464

D 13709
L 3.5

(DL) 47981.5
Log. (DL) 4.681
3

4)14.043

Log. $(DL)^{\frac{3}{4}}$ 3.5108
$(DL)^{\frac{3}{4}}$ 3242
$.052n$ .104

Weight 337.16

Wt. of Propellers.

$D\sqrt{s} = 14.75\sqrt{68} = 121.69$
− 36.30
85.39
$.11n$ = .22

Weight 18.78

Weight of Shafting, Etc.

Crank, $D^2L = 16^2 \times 57.76 = 14786.6$
Thrust, " $= 15.75^2 \times 38.88 = 9644.6$
Line, " $= 15.75^2 \times 70.00 = 17364.2$
Prop'r, " $= 16^2 \times 78.00 = 19968.0$
61763.4
.0026
159.76

Crank $d^2L = 7.5 \times 57.76 = 3361.5$
Thrust " $= 7.5 \times 38.88 = 2187.0$
Line " $= 7.5 \times 70.00 = 3937.5$
Prop'r " $= 7.5 \times 78.00 = 4387.5$
12873.5
.0012
− 15.45

Weight 144.31

Wt. of Water in Boilers.

Double ended:—

$D^2L = 15.25^2 \times 21.25 =$ 4941.9

A $\left\{\begin{array}{l} \frac{HS \times d}{12\pi} = \frac{5659.7 \times 2.25}{12 \times 3.14} = 338.7 \\ nf^2l = 8 \times 3.25^2 \times 7.66 = 786.0 \end{array}\right.$

1124.7
$.0117N$ = .0468
1078.64

Single ended:

$D^2L = 15.25 \times 10.96 =$ 2548.9

A $\left\{\begin{array}{l} \frac{HS \times d}{12\pi} = \frac{2829.9 \times 2.25}{12 \times 3.14} = 169.35 \\ nf^2l = 4 \times 3.25^2 \times 7.6 = 389.73 \end{array}\right.$

559.1
1989.8
$.0117N$ = .0234
1046.56 1046.56
225.20
Less weight of 2 inches = 6.57
Weight = 218.63

Boiler-Room Weights.

Double ended:—

$D^2(L+2) = 15.25^2 \times 23.25 =$ 5407.0
HS = 5659.7
11066.7
.0093
102.92
N = 4
411.68
$5N$ = + 20.00
Weight 4 D. E. 431.68

Single ended:—

$D^2(L+2) = 15.25^2 \times 12.96 =$ 3014.0
HS = + 2829.9
5843.9
.0085
49.68
N = 2
99.34
$10N$ = + 20.00
Weight 2 S. E. 119.34
" 4 D. E. 431.68
Total weight 551.02

Summary.

Engine-room	337.16
Shafting, etc	144.31
Propellers	18.78
Boilers	551.02
Water	218.63
Total weight	1269.90

weights of water tube boilers, and, as they are at present largely in the experimental stage, it was deemed desirable to postpone the discussion of their weight until a future occasion.

ADDENDA.

Since this paper was written it has occurred to the writer that in certain cases it might be desirable to estimate the weight of, boilers and

MACHINERY OF MERCANTILE SCREW STEAMERS.

Name of vessel.	Atlantic liner. 1	Brazilian coaster. 2	West India trader. 3	Coasting steamer. 4	Ocean tug. 5	Atlantic cattle steamer. 6	Coasting steamer. 7	Brazilian coaster. 8
ENGINES—								
Number of sets	1	1	1	2	2	1	1	1
Type	V. C.	V. C.	V. C.	V. C.	V. C.	V. C.	V. T.	V. T.
Number of cranks	3	2	2	2	2	2	3	3
Diam. H. P cyl. (inches)	63	35	32	30	21	48	29	27
" I. P. " "	—	—	—	—	—	—	44	40.5
" L. P. " "	(2) 91	70	63	60	42	90	70	61
Stroke (feet)	5.5	3.75	3.75	3.0	2.7	5.0	4.0	3.75
Revolutions	68	73.3	74	78.7	77.3	55.6	80	83.5
I. H. P	8500	1924	1510	2516	1105	2700	3200	2339
SHAFTING—								
Total length of crank (feet)	31.08	14.5	13.0	26	19.2	19.33	20.42	18.0
" " thrust "	82.30	60.83	70.1	83	64	68	71.16	81.31
" " line "								
" " propeller "	36.00	31.88	27.5	70	60	120.33	24	24.66
Diam. of crank (inches)	22	12¾	12	11	8½	17	14	12¾
" thrust "	20	12	11¼	10½	8	15¾	12¾	12
" line "								
" propeller "	22	12½	11¾	11	8½	17	13½	12½
Diam. of hole, crank (inches)	—	—	—	—	—	—	—	
" " thrust "	—	—	—	—	—	—	—	
" " line "	—	—	—	—	—	—	—	
" " propeller "	—	—	—	—	—	—	—	
PROPELLERS—								
Number	1	1	1	2	2	1	1	1
Diameter (feet)	22.0	14.25	14.5	12.0	11.0	20.0	15.0	14.25
Pitch "	29.0	19.00	17.25	20.0	14.0	22.5	22.75	18.00
Surface (one) (sq. ft.)	164	80	70	66	36	85	73	64
Number of blades	4	4	4	4	4	4	4	4
*ENG. ROOM WTS. (tons)	672.4	177.45	127.75	232.65	111.63	336.55	195.9	179.7
Do. ÷ I. H. P.	.079	.0923	.0846	.0925	.101	.125	.0612	.0769

* Recorded weights.

Name of vessel.	Atlantic liner. 9	Atlantic liner. 10	Brazilian coaster. 11	Channel steamer. 12	Coasting steamer. 13	Coasting steamer. 14	Great Lake steamer. 15	Campania. 16
ENGINES—								
Number of sets	2	1	1	2	1	1	1	2
Type	V. T.	V. T.	V. T.	V. T.	V. T.	V. T.	V. T.	V. T.
Number of cranks	3	3	3	3	3	3	3	3
Diam. H. P. cyl. (inches)	45	35.5	27	24	13.5	13.5	22	(2) 37
" I. P. " "	71	56	40.5	37	22	22	35	79
" L. P. " "	113	89	61	56	34	34	56	(2) 98
Stroke (feet)	5.0	4.5	3.75	2.75	2.0	2.0	3.66	575
Revolutions	91	74	85	172	106	79.5	—	—
I. H. P.	20120	4500	2230	5550	450	325	—	—
SHAFTING—								
Total length of crank (feet)	69.0	24.5	18.0				30	140
" " thrust "	170.0	138.13	87.25	112	90	75	60	246
" " line "								
" " propeller (ft.)	203.2	27.00	24.66					
Diam. of crank (inches)	20¼	17	12¾					26
" thrust "	19¼	16	12	11	6	6	12¼	24
" line "								
" propeller "	20½	18	12½					
Diam. of hole crank (inches)	3½	—	—	—	—	—	—	—
" " thrust "	—	—	—	—	—	—	—	—
" " line "	—	—	—	—	—	—	—	—
" " propeller "	—	—	—	—	—	—	—	—
PROPELLERS—								
Number	2	1	1	2	1	1	1	2
Diameter (feet)	19.5	19.0	14.25	11.0	10.0	10.75	13.16	20 ?
Pitch	28.0	21.5	18.00	13.75	8.42	11.00	16.0	—
Surface (one) (sq. ft.)	96	90	64	29	25	30	64	140 ?
Number of blades	3	4	4	3	4	4	4	3
*ENG. ROOM WTS. (tons)	1293.0	417.1	182.0	224.4	42.15	43.4	?	?
Do. ÷ I. H. P.	.0643	.0927	.0816	.0405	.0937	.134	—	—

* Recorded weights.

mountings only, separate from the other boiler formulae, under the head, "Boiler Room

MACHINERY OF MERCANTILE SCREW STEAMERS.

Name of vessel.	Atlantic liner. 1			Brazilian coaster. 2	West India trader. 3	Coasting steamer. 4	Ocean tug. 5	Atlantic cattle steamer. 6
Main Boilers—								
Type	Scotch D. E.	Scotch D. E.	Scotch S. E.	Scotch D. E.	Scotch D. E.	Scotch D. E.	Scotch S. E.	Scotch D. E.
Working pressure	95	95	95	90	90	100	100	90
Number	3	3	1	2	1	2	2	2
Diameter (feet)	14.42	14.25	14.66	12.75	14.58	13.50	12.75	18.00
Length "	17.50	17.50	11.00	15.00	17.50	16.66	10.00	17.50
Total heating surface		22749		4748	3300	5154	2270	10000
" grate "		865		189	126	240	103.5	360
One boiler. Furnaces, No. and type	6 corrugated	6 corrugated	3 corrugated	6 corrugated	6 corrugated	6 corrugated	3 plain.	8 corrugated
" diameter (feet)	3.38	3.38	3.42	3.16	3.42	3.5	3.0	3.75
Tubes, diameter (inches)	3½	3½	3½	3	3½	3¼	3½	3½
" length (feet)	7.0	7.0	7.5	5.88	7.0	6.7	6.95	7.0
" heating surface	2977.33	2910.0	1943	1872.5	2840	2159.5	917	4310
Plate, " "	479.33	467	305	501.5	460	412.5	218	690
Total " "	3456.66	3377	2248	2374.0	3300	2572	1135	5000
Height of water (inches)		8		8	—	8	8	?
Auxiliary Boilers—								
Type and number		1 Scotch.		1 vertical.	1 vertical.	1 vertical.	—	1 Scotch.
Diameter and length (feet)		10×9		4.5×9.4	6×13	4×5	—	10×9
Heating surface		710		73.5	159	190	None.	620
Grate "		40		10.5	22	13	—	—
Boiler-Room Wts. (tons)		783.94		165.11	128.25	187.5	105.9	355.90
Do. ÷ I. H. P.		.0922		.0858	.0849	.0745	.0959	.132
" ÷ heating surface		.0345		.0348	.0389	.0364	.0467	.0356
" ÷ grate "		.906		.873	1.018	.781	1.023	.989
Weights by Formulæ—								
Engines		481.48		124.83	105.53	162.00	86.50	248.02
Shafting		169.95		41.87	37.80	53.91	25.33	83.68
Propellers		16.95		10.01	9.35	13.44	6.52	16.28
Main boilers		496.99		105.56	73.82	121.20	72.46	220.51
" " water		218.60		44.37	33.72	54.35	31.18	103.30
Auxiliary boilers and water		27.90		5.88	10.51	7.98	—	27.90
Estimated total weight (tons)		1411.87		332.52	270.73	412.88	221.99	699.19
Recorded " " "		1456.34		342.56	256.00	420.55	217.53	692.45
Error per cent.		−3.0%		−2.9%	+7.3%	−1.8%	+2.0%	+1.0%

Name of vessel.	Coasting steamer. 7	Brazilian coaster. 8	Atlantic liner. 9	Atlantic liner. 10		Brazilian coaster. 11	Channel steamer. 12	Coasting steamer. 13
Main Boilers—								
Type	Scotch D. E.	Scotch D. E.	Scotch D. E.	Scotch D. E.	Scotch S. E.	Scotch D. E.	Scotch D. E.	Scotch S. E.
Working pressure	150	150	150	160	160	160	160	160
Number	2	2	9	3	1	2	2	2
Diameter (feet)	13.5	13.16	15.5	13.58	14.83	13.16	15.0	8.83
Length "	16.0	15.0	19.13	17.75	11.00	15.0	18.83	9.0
Total heating surface	6648	5204	50040	13174		5204	12110	1280
" grate "	208	180	1293	408		180	300	?
One boiler. Furnace, No. and type	6 corrugated	6 corrugated	6 corrugated	6 corrugated	3 corrugated	6 corrugated	8 corrugated	2 Brown.
" diameter (feet)	3.16	3.16	3.83	3.2	3.2	3.16	3.0	2.33
Tubes, diameter (inches)	2½	2½	2½	2½	2½	2½	2½	—
" length (feet)	6.25	5.88	7.5	7.15	7.15	5.88	7.25	—
" heating surface	2880	2215	4990	3066.6	2279	2215	—	—
Plate, " "	444	387	570	456	327	387	—	—
Total " "	3324	2602	5560	3522.6	2606	2602	6055	640
Height of water	8	8	8	8	8	8	8	—
Auxiliary Boilers—								
Type and number	1 Scotch.	1 Scotch.	2 Scotch.	2 Scotch.		1 Scotch.	1 Scotch.	None.
Diameter and length	7×7	6.3×7.3	8.7×9.5	10×9		6.3×7.3	7×7.5	
Heating surface	236	230	522	695		230	230	
Boiler-Room Wts. (tons)	204.7	187.0	1457	480.5		187	307	51.66
Do. ÷ I. H. P.	.0758	.0800	.0674	.107		.0838	.0553	.115
" ÷ heating surface	.0308	.0359	.0271	.0365		.0359	.0253	.0404
" ÷ grate "	.984	1.039	1.05	1.178		1.039	1.02	?
Weights by Formulæ—								
Engines	158.90	124.22	861.80	261.70		124.22	166.53	30.54
Shafting	51.85	48.06	458.34	133.09		50.31	70.47	8.42
Propellers	10.09	8.54	40.18	15.83		8.54	5.04	1.50
Main boilers	132.85	113.02	935.24	271.45		113.02	209.81	45.22
" " water	54.38	48.50	375.50	114.62		48.50	77.55	15.10
Aux. boilers and water	10.63	9.01	44.23	55.80		9.01	13.08	—
Estimated total weights (tons)	418.70	351.35	2715.29	852.49		353.60	542.48	100.78
Recorded " " "	400.60	366.70	2650.00	897.60		369.00	531.40	93.81
Error, per cent.	+4.5%	−4.2%	+2.4%	−5.0%		−4.2%	+2.1%	+7.4%

room weights which are included in the general Weights" (page 20 February issue). For this

purpose the formulae on page 20 will approximate closely to the desired weight.

The weight obtained by this formulæ includes, weight of boilers complete; tubes ordinary and stay grates, bearing bars, bridges, furnace fronts and doors, firebricks and other fittings, stop, safety, check, blow and other valves, internal piping, hydrokineters, circulating plates, lagging including angle iron, etc., for securing them.

MACHINERY OF MERCANTILE SCREW STEAMERS.

Name of vessel.	Coasting steamer. 14	Great lake steamer. 15	Campania. 16	
MAIN BOILERS—				
Type	Scotch S. E.	Scotch S. E.	Scotch D. E.	Scotch S. E.
Working pressure	160	170	160	160
Number	1	2	12	1
Diameter (feet)	10.0	13.5	18.0	18.0
Length "	10.0	12.2	17.0	11.0
Total heating surface	937	4130	75000 ?	
" grate "	30	?		
One boiler. Furnaces, No. and type	2 Brown.	2 corrugated	4	4
" diameter (feet).	2.75	4.0	—	—
Tubes, diameter (inches)	2¾	2½	3	3
" length (feet)	—	8.25	—	—
" heating surface	—	—	—	—
Plate, " "	—	—	—	—
Total " "	937	2065	—	—
Height of water	8	—	—	—
AUXILIARY BOILERS—				
Type and number	1 vertical.	1 vertical.	1 Scotch.	
Diameter and length (feet)	3.5×7.5	4×8.8	10×10	
Heating surface	—	—	—	
Grate "	—	—	—	
BOILER-ROOM WTS. (tons)	42.20	?	?	
Do. ÷ I. H. P.	.130			
" ÷ heating surface	.045			
" ÷ grate "	1.407			
WEIGHTS BY FORMULÆ—				
Engines	30.54	101.12	907.92	
Shafting	7.49	24.38	614.47	
Propellers	1.77	7.83	44.26	
Main boilers	28.16	95.70	1487.91	
" " water	11.85	43.96	659.00	
Aux. boilers and water	5.15	4.30	31.00	
Estimated total weights (tons)	84.96	277.29	3744.56	
Recorded " " "	81.10	260.80	?	
Error, per cent	+ 4.7%	+ 2.5%	?	

[From a paper read before the Society of Naval Architects and Marine Engineers, at the fifth general meeting. The preceding chapter appeared in our February issue. An interesting query and reply concerning this paper will be found on page 37 of this issue.—ED.]

Loss of the British Ship Blairmore.

Lying on the mud banks of the estuary at Oakland, Cal., is the hulk of the British ship Blairmore. Captain John Caw, who brought the vessel out here from England about two years ago, is anxiously awaiting the decision of the highest court of the United Kingdom in the matter of the Blairmore Ship Company vs. the English Insurance Companies. The story of the Blairmore is one of the strangest in the annals of Pacific coast marine disasters. Though much has been said concerning the ship's crew and the awful death of seven of their number during the storm in the bay of San Francisco on April 9, 1896, little has been recorded concerning the later developments in the case; successful attempts to raise her and the litigation that has followed these attempts.

From all appearances the "Blairmore" is a complete wreck. She lies low in the mud, with two stumps of masts, main and mizzen, showing above her bulwarks. Her deck houses are intact, but her decks are strewn with wreckage of rigging and spars. A temporarily patched up plate is hidden by the mud of the starboard side amidships, and about four feet from the keel; otherwise the hull is in a good state of preservation, though to the eye of the inexperienced it seems to be a worthless mass of rusty iron.

On the morning of April 9, 1896, news was received at the Merchants' Exchange, San Francisco, that a British ship had been "tripped" by her anchor in the south wing of the bay and capsized. This was about 7.30 o'clock. Fifteen minutes later the writer, on the tug Millie, left the Clay street dock for the scene of the disaster, which was at a point opposite the Union Iron Works Ship Yard at South San Francisco. The weather was squally and a light rain was falling. Quite a sea was running, but judging from the nature of the storm it did not seem possible that an accident of a serious nature could have been caused by the blow. The tide was at the flood. Not a sign of the Blairmore was visible above the waves.

The Millie steamed alongside of the iron works dock and there it was learned that the Britisher had capsized during a squall of unusual severity, that all but seven members of her crew had been picked up by boats from ships anchored near by and that Captain Caw had hurried to the British Consulate for assistance. The first officer and six seamen had been working in the hold when the ship capsized, and were drowned, as was learned later.

Very little could be done except cruise about the spot where the ship had been anchored and take soundings. Five, and five and two-thirds fathoms of water were logged. The starboard bilge of the ship was located about 3 ft. below the surface for a distance of 50 ft. or more. The tide had turned and was rapidly out. At 9.30 o'clock the hull showed 2 ft. above the water and appeared to have some buoyancy. The weight of the masts probably held it down.

A peculiar sound came from within the hull. It was subsequently found that the noise was caused by a rush of air within, but it was first mistaken for the voices of those imprisoned within the steel tomb. Word was sent to the Union Iron Works and a number of mechanics in charge of Superintendent Dickie rowed to the

wreck in a small boat. Four men, with sledges and chisels, cut a hole 2 ft. dia. in the plate. The opening of the hull was followed by a great rush of air, and the hull settled in the mud a couple of feet.

The Blairmore was insured for $50,000, but the owners, instead of turning the wreck over to the Marine Underwriters, undertook to raise her themselves. Captain Burns, an expert wrecker, was sent to San Francisco from England, and on arrival he secured the services of the wrecking steamer T. P. H. Whitelaw, the only craft in the harbor mechanically fitted to undertake so difficult a task.

The Whitelaw's divers first removed the upper spars and yards of the wreck. Water tanks were then rigged out on platforms attached to the starboard topsides of the ship at such an angle as to place the center of gravity of the tanks at a point beyond the turn of the bilge. Then the powerful pumps of the tugboat Fearless were started and the tanks filled. The "Whitelaw" attached chain gear to the stumps of the fore and mizzen masts, slung out its great derricks and lifted on the spars. Prior to this work the hole in the bilge was temporarily closed with a lap plate.

On June 23, 1896, the Blairmore was righted and towed to the flats at Oakland. On July 18 she was towed back to the Union Iron Works, but as litigation between owners and insurance companies had by this time commenced, the ship was towed back to the flats, where she has remained until this day.

The owners had spent $35,000 to raise the ship. They attempted to recover the full $50,000 from the underwriters. The insurance men alleged that the hull should have been turned over to them immediately after disaster. They have won their case in two courts in England, and the matter is now on appeal before the highest tribunal of the Old Country.

On April 16, 17, and 18 the naval court of inquiry in the Blairmore case was held in San Francisco, before British Vice-Consul Wellesley Moore, acting for Consul Warburton, absent in England. Captain Caw testified that the Blairmore was a Glasgow built ship of 1,767 tons register, and that she had on board at the time of the accident 270 short tons of ballast. Lengthy testimony was introduced to prove that the disaster was not the fault of the officers of the ship, but was caused by a peculiar combination of circumstances made plain in the finding of the court which held that the master of the "Blairmore" had not been negligent in providing, as he believed, sufficient ballast for the ship, the stability of which had never been called in question. That the crew was at work in the hold at the time of the mishap was an unfortunate circumstance. The ship was capsized by a heavy squall while riding ahead of her anchor, forcing the ship across the cable, which tightened with the strain, causing her to swing across the tide.

REPORT OF THE "MAINE" NAVAL COURT OF INQUIRY

A SUBMARINE MINE CAUSED THE PRIMARY EXPLOSION.

Finding of the Court Containing this Conclusion—Lengthy Extracts from the Testimony in the Original Text—Reproduction of Many Official Views and Drawings of the Wreck.

(Second Installment.)

In continuation of the evidence of Lieutenant George F. M. Holman, U. S. N.

Q. How much powder was stowed in the forward 10-inch magazine?

A. I think there were about 150 or 160 tanks, representing seventy-five or eighty charges, say, approximately, some of these being full and others reduced charges, some 125 pounds to the tank, that being the weight of one of the tanks of a full charge. These figures I give I cannot be exact in.

Q. I suppose there were about as many shell in the shell rooms as there were full charges in the magazine?

A. Yes, probably the same number.

Q. How was the fixed-ammunition room forward located?

A. Over near the midship line of the vessel, abaft the 6-inch magazine.

Q. Can you state approximately what that contained at the time of the explosion?

A. That contained 6-pounder and 1-pounder shell and small-arm—that is, rifle and 6-millimeter—ammunition. I cannot say how much.

Q. What was in the forward 6-inch magazine?

A. About two hundred or more 6-inch charges and a corresponding number of shell in the shell room adjoining.

Q. On which side was the powder stowed?

A. A little over to the port side of the midship line.

Q. In the 10-inch magazine forward the powder was to starboard of the shell, was it not?

A. Yes.

Q. You have stated that you were also the electric officer of the ship. Will you please state what wiring went down into the magazines and shell rooms? I mean the forward one.

A. None. There were electric lamps in the light boxes, and wires leading to these lamps, but they were separated from the magazine by a double plating of glass.

Q. Were there any steam pipes in dangerous proximity to the magazine or shell room?

A. No.

Q. Were you on board at the time of the explosion?

A. Yes.

Q. Did you notice any serious action of the electric light which would indicate grounding just previous to the explosion?

A. No.

Lieutenant Commander Richard Wainwright, executive officer of the "Maine," in the course of his examination, was asked:

Q. What was the discipline on the part of the officers and men immediately following the explosion?

A. I consider it excellent. All orders were obeyed with the promptness of a drill. The captain told me what orders he wished me to give, and the only order not promptly obeyed was the final order to leave the ship, and the officers hesitated until it was given in an imperative manner.

Q. Will you please describe the wreck as you found it after you had a full chance to examine it by daylight?

A. The after part of the ship appeared to be intact from the crane aft, with a heavy list to port, the port turret being about 2 feet under water. The main deck was folded back, carrying the central superstructure with it at a line between the two cranes and about the line between the two fire rooms. It was folded in a direction from port to starboard, so that the port 6-inch gun was lying nearly over the starboard 6-inch gun, the conning tower pointing downward about where the armory was—that is, the starboard after corner of the superstructure. The forward smokestack was lying abreast and partly over where the first whaleboat hung; the siren was on the starboard side of the after superstructure. The after smokestack was lying on the port side abreast of the fore-and-aft bridge, between the after and central superstructure. At the lowest tide we had I stood on the port waterways, and could see nothing that I could recognize as any part of the ship forward of the crane on the port side of the main deck.

There were some portions of the wreck forward of this line mentioned on the starboard side. By looking in underneath it I saw a torpedo port, apparently of the starboard forward torpedo. I recognized part of the washroom—I believe it was part of the foremen's washroom—immediately abaft the starboard turret having a small scupper with a lip, a holddown valve, and also a half round bulkhead separating portions of the washroom. Forward of that again I recognized pieces of bottom plating with anchor scars. They had a triangular piece that led me to believe it to have been under the starboard anchor. Forward of that was some wreckage with old rope, which I think had been where the anchor gear was stowed. Forward of that one of the fore yardarms was sticking up. As far as I can tell from the above water view, there is an angle between the after body of the ship and the forward, with an apex to starboard.

Chief Engineer Charles P. Howell, of the "Maine," gave testimony regarding the location of the bunkers in the vessel, and was asked:

Q. What coal bunkers on board the *Maine* are adjacent to the magazines in the forward half of the ship; I mean magazines and shell rooms?

A. If I could refer to the blue print I could tell you the numbers of them. A15 is on the forward starboard side under the forward turret. That is adjacent to the 10-inch magazine. A16 is similarly situated on the port side, and that is adjacent to the 6-inch reserve magazine, I think they call it. B3 is on the starboard side, and B5 is also on the starboard side. They are adjacent to the magazine. B4 and B6 are on the port side, also adjacent to the 6-inch reserve magazine.

Q. The first two are adjacent to the 10-inch magazine?

A. Yes, sir. Perhaps I could state that a little better now, as I first went from the starboard side to the port side and back again.

Q. Go ahead in your own way. Make it as plain as you can.

A. On the starboard side, adjacent to the 10-inch magazine, are coal bunkers A15, B3, and B5. On the port side, adjacent to the 6-inch reserve magazine, are coal bunkers A16, B4, and B6.

Q. Please state to the court, as near as you can recollect, the history of coal bunker A15, from the time you joined the ship up to the time of the explosion?

A. A15 is a bunker which it is difficult to put coal in or to take coal out of, and, besides, you have to go through B4 and B5. To take coal out of A15 you first have to empty B3 and B5, and to put coal in A15 you have to partially fill B5, and then fill from B5 into A15. As I say, it is a difficult bunker to put coal in and take coal out. Those bunkers forward have been emptied as frequently as possible in order to lighten the ship forward. We have always tried to take coal out of the forward bunkers as much as possible, because when they are full the ship has a tendency to go down forward. It was the same way on the port side. A16 is a difficult bunker to fill, and is the last one that is emptied on the port side, because we have to take coal out of B4 and B6 before we can take any out of A16.

Q. Have you always inspected coal on board the *Maine* before receiving it?

A. Yes, sir.

Q. Have you, during the time you have been chief engineer of the *Maine*, had any signs of any kind of spontaneous combustion in the coal bunkers?

A. No, sir; none whatever. In connection with that I have frequently examined the different bunkers all around everywhere, and the different kinds of coal. I have never seen any signs whatever of any bunker heating. I have examined them from the outside, and when they have taken coal out of them; also particularly when we have taken in coal that I thought was more liable to spontaneous combustion than other coal. I have never seen any signs of heating.

Q. When did you make your last examination of these bunkers, previous to the explosion?

A. Bunkers B3, B5, B4, and B6—unless you want to consider some others, I will not mention any others—are emptied, and they have been emptied about two weeks.

Q. That is, previous to the explosion?

A. Yes, sir; B3, B5, B4, and B6.

Q. Those have been empty?

A. They have been empty ten days or two weeks. All of those have been entirely empty. In that time we have painted all those bunkers and we have scaled them. Also we have scaled the chutes that led down to them, and painted them. A15 was about half empty until the day of this explosion. On that day, at 4 o'clock, we began taking coal from A15, to keep the ship on an even trim. I have not been in that bunker personally since they began taking coal out of it, though I have passed around these bunkers, and I felt of them within a week on both sides. I have been to the wing passages, and every time I go through there I can feel those bunkers. I pass right by the bunkers. It is a quarter of an inch thick, and I put my hand on them. I never have gone through there without putting my hand on them to feel the temperature.

Q. You never found any signs of heating?

A. I never found any signs of heating—any variation.

Q. Regarding the steam piping of the *Maine*, was there any piping in dangerous proximity to the forward magazines or shell rooms?

A. No, sir.

Q. Did any steam pipes lead through bunker A16?

A. No, sir.

Q. What boilers were in use at the time of the explosion?

A. The two aftermost boilers in the ship, one on each side.

Q. What was the condition of those boilers?

A. In good condition. We were in the habit of carrying about 80 to 100 pounds of steam in port.

Q. For auxiliary purposes?

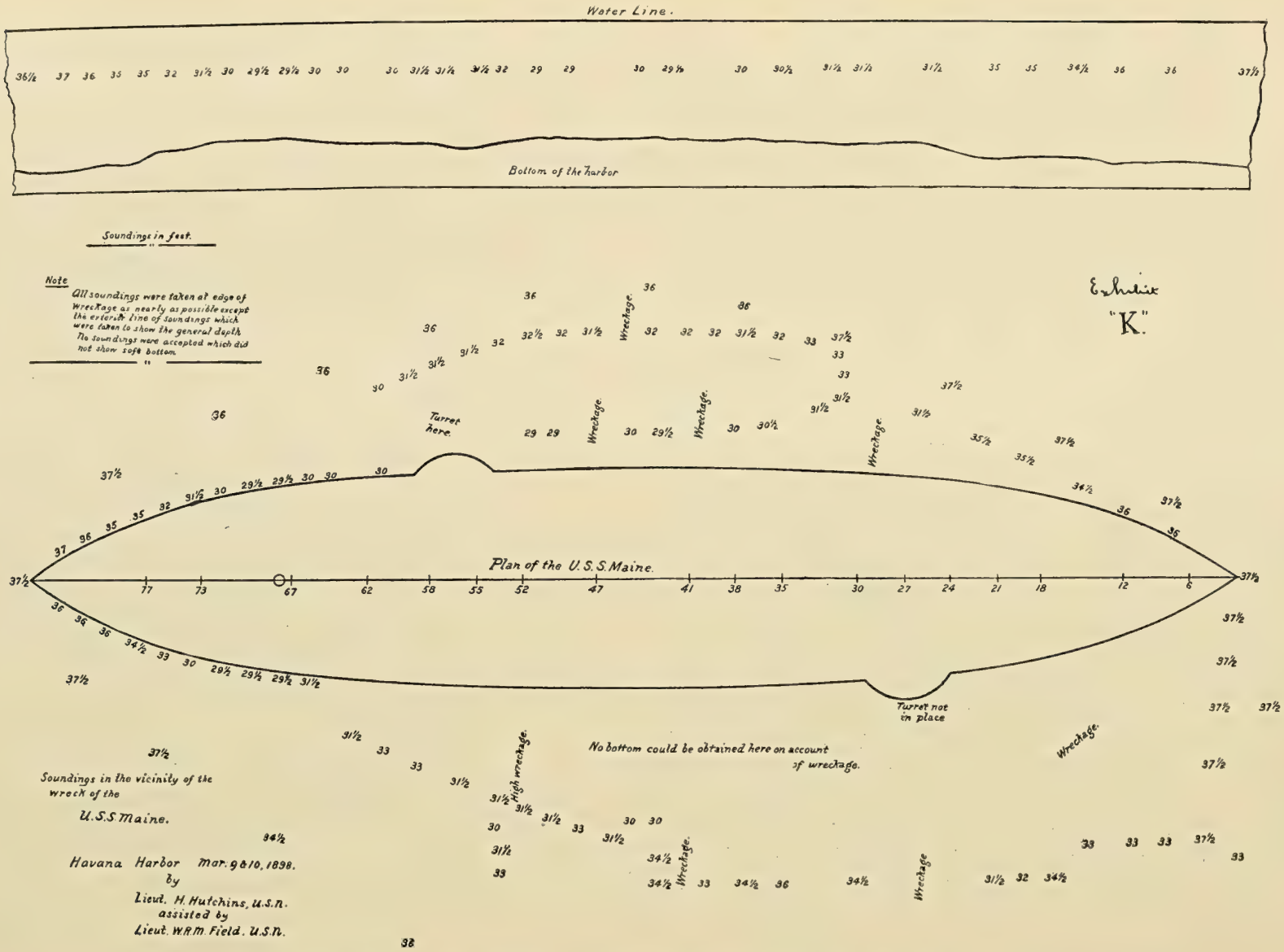
A. For auxiliary purposes, in port.

Q. How much did you carry in those same boilers when steaming at sea?

A. One hundred and twenty pounds.

Q. In your opinion it would have been impossible for those two boilers to explode with the pressure they were carrying?

A. Yes, sir; the explosion would not have done much damage under ordinary circumstances.


Water Line.
Bottom of the Harbor
Soundings in feet.
Note
All soundings were taken at edge of Wreckage as nearly as possible except the extreme line of soundings which were taken to show the general depth. No soundings were accepted which did not show soft bottom.
Exhibit "K."
Turret here.
Wreckage.
Plan of the U.S.S. Maine.
Turret not in place
No bottom could be obtained here on account of wreckage.
High wreckage.
Soundings in the vicinity of the wreck of the U.S.S. Maine.
Havana Harbor Mar. 9 & 10, 1898.
by
Lieut. H. Hutchins, U.S.N.
assisted by
Lieut. W.R.M. Field. U.S.N.

SURVEY OF SOUNDINGS AROUND THE WRECK OF THE "MAINE," MADE FOR THE NAVAL COURT OF INQUIRY.

Paymaster Charles M. Ray, of the U. S. S. Maine, testified:

Q. Referring to your storerooms in the forward part of the *Maine*, was there any inflammable or dangerous matter stowed in any of those storerooms?

A. Not to my knowledge and belief, sir.

Q. What was stowed forward belonging to your department, and where was it stowed?

A. I think thehe are the only two rooms I had [indicating on blue print]. There was stored in them preserved meats, small stores, and some clothing.

Ensign W. V. N. Powelson, who was serving on the "Fern," which was sent to Havana immediately following the explosion, and who had charge of the divers, said in response to an inquiry:

A. The divers do not seem to be able to express themselves as to what they see down below. I have talked to them and have not been able to learn very much.

Q. That is the difficulty; they do not know what they find.

A. They see things there, but they do not know exactly what they are or what the conditions are.

Chief Engineer Howell, recalled, was asked:

Q. What instructions did you have from your commanding officer in regard to old cotton waste that had been used?

A. We have a number of copper tanks in the engine room and fire room, about 22 inches high and 15 inches in diameter, with covers on them. They are kept there for the purpose of putting old refuse in them, and oil waste and anything of that style that has been used. Every day they are carried away, thrown in the ash pile and thrown overboard.

Captain Frederick G. Teasdale, master of the British bark Dera, which was lying in Havana harbor, was asked where he had been at the time of the explosion, and he replied:

A. Sitting at the cabin table writing when I heard the explosion. I thought the ship had been collided with. I ran on deck when I heard the explosion. I felt a very severe shock in my head also. I seized my head this way [indicating]. I thought I was shot, or something. The transoms of the doors of the cabin are fitted in the studs on the side, and they were knocked out of place with the shock. The first seemed to be a shot, and then a second, or probably two seconds, after the first report that I heard, I heard a tremendous explosion; but as soon as I heard the first report—it was a very small one—thinking something had happened to the ship, I rushed on deck, and was on deck just in time to see the whole débris going up in the air.

Q. Please describe, as graphically as you can, how this appeared to you—what you saw.

A. The stuff ascended, I should say, 150 or 160 feet up in the air. It seemed to go comparatively straight until it reached its highest point of ascent. Then it divided and passed off in kinds of rolls or clouds. Then I saw a series of lights flying from it again. Some of them were lights—incandescent lights. Sometimes they appeared to be brighter, and sometimes they appeared to be dim, as they passed through the smoke, I should presume. The color of the smoke, I should say, was very dark slate color. There were fifteen to twenty of those lights that looked like incandescent lights. The smoke did not seem to be black, as you would imagine from an explosion like that. It seemed to be more a slate color.

Q. Was there anything that appeared to you to be shooting stars or anything like that?

A. No; I never saw anything like that; only a series of smaller explosions, after the first one, you know. That occurred at stated intervals, probably twenty minutes or half an hour each. You would hear small reports from the deck, as if they were scattered shells about the deck which were going off, but they would not do any harm; some going in one direction and some in another.

Q. Did you see any dead fish around the bay?

A. I never saw any; no, sir.

Q. Have you ever heard that fish leave this harbor at night and go outside?

A. I never heard any remark about that. I have seen a good many fish here, but they were very small fish, just spluttering about on the top of the water. I have never seen any in the night time, but any time when there is any spluttering among the fish it generally occurs in the daytime, so far as my observation has gone. The wind coming in that direction carried a lot of light material over our vessel that night. Quantities of paper and small fragments fell over our ship, and for some time after. I picked up some boiler coating or coating for steam pipes the next morning. There also seemed to be felt and hair.

Sigmond Rothschild, of Detroit, a passenger on the Ward liner City of Washington, who was an eye-witness of the disaster, described his impressions:

Q. How far was the *City of Washington* from the *Maine* at the time of the explosion?

A. I cannot give the exact distance, but I asked Captain Stevens, captain of the *Washington*, what distance he would call it, and he said about 300 feet.

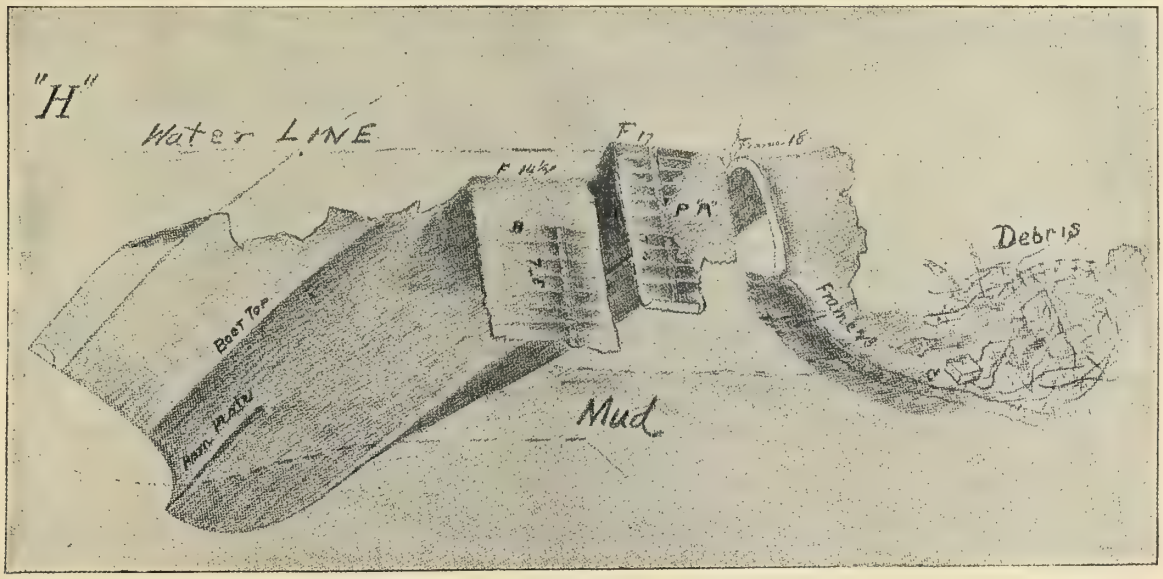
Q. Where were you at the time it happened?

A. Right on the stern of the boat. I had brought my chair just about in this condition [indicating], and had not sat down when I heard a shot, the noise of a shot. I looked around and saw the bow of the *Maine* rise a little, go a little out of the water. It couldn't have been more than a few seconds after that noise, that shot, that there came in the center of the ship a terrible mass of fire and explosion, and everything went over our heads, a black mass. We could not tell what it was. It was all black. Then we heard a noise of falling material on the place where we had been, right near the smoking room.

One of the lifeboats which was hanging had a piece go through it and make a big hole in it. After we seen that mast go up, the whole boat lifted out, I should judge, about 2 feet. As she lifted out, the bow went right down. It didn't take a minute after the lifting of the boat until the bow went down. We stood spellbound, and cried to the captain. The captain gave orders to lower the boats, and two of the boats which were partly lowered were found broken through with big holes. Some iron pieces had fallen through them. Naturally, that made a delay, and they had to run for the other boats, or else we would have been a few minutes sooner in the water. Then the stern stood out like this, in this direction [indicating], and there was a cry from the people "Help," and "Lord God help us," and "Help! Help!" The noise of the cry from the mass of human voices in the boat did not last but a minute or two. When the ship was going down, there was the cry of a mass of people, but that was a murmur. That was not so loud as the single voices which were in the water. That did not last but a minute, and by that time we saw somebody on the deck in the stern of the ship, and it took about a few minutes when the boats commenced to bring in the officers. We took them to our rooms. A great many of them came without anything on but a pair of pants and nothing else. That is about the whole story in regard to the shot.

Chief Gunner's Mate Andrew Olsen of the U. S. S. Iowa, who had been at work on the wreck of the "Maine," diving, was asked:

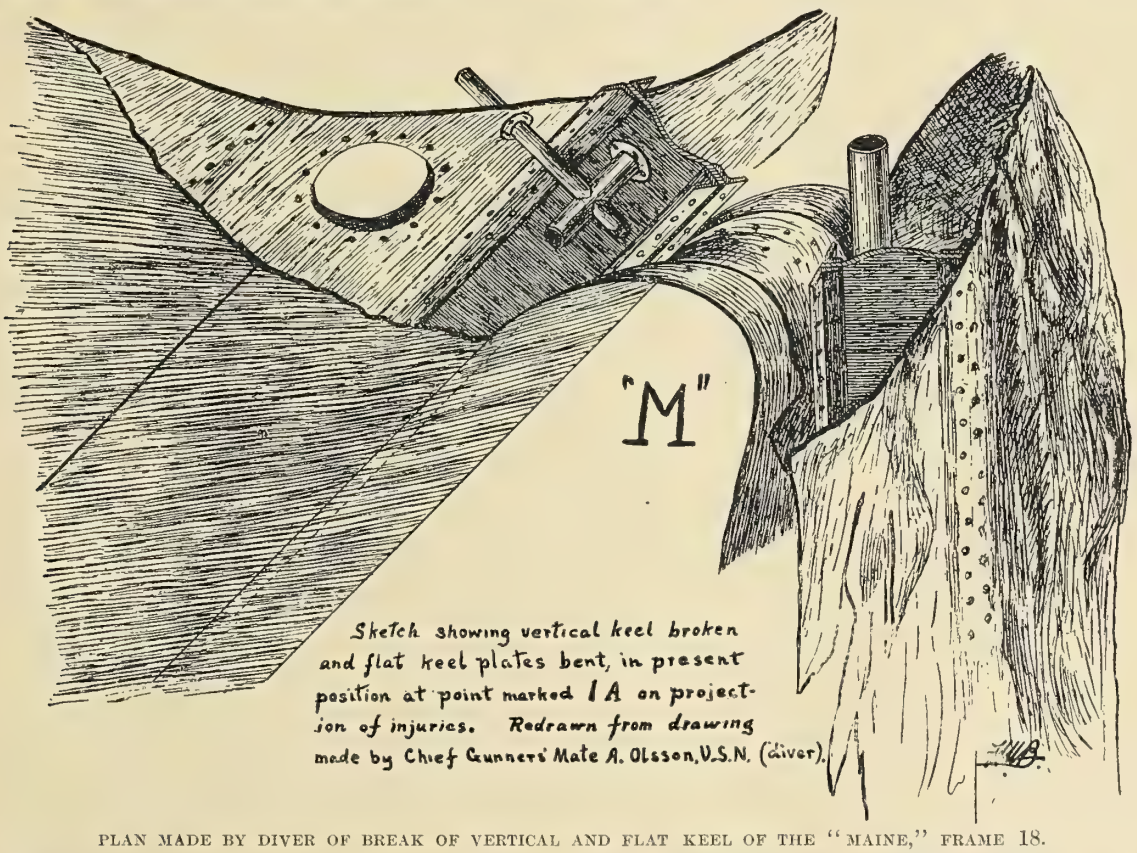
Q. Were you using any electric lights in diving?
A. Yes, sir; but the electric light was not much use to me. It merely showed a red glare, and I came to the conclusion that I was better without the light.



FORWARD PART OF THE "MAINE" UNDER WATER, KEEL ABOUT AS FAR AFT AS FRAME 28.

Gunner's Mate Thomas Smith, of the "Iowa," who had done similar work, was asked:

a rather sensational incident in the attendance of a Cuban witness whose name and address were suppressed by agreement. The chief portions of the story he related to the court are as follows:


"M"
Sketch showing vertical keel broken and flat keel plates bent, in present position at point marked 1 A on projection of injuries. Redrawn from drawing made by Chief Gunners' Mate A. Olsson, U.S.N. (diver).

PLAN MADE BY DIVER OF BREAK OF VERTICAL AND FLAT KEEL OF THE "MAINE," FRAME 18.

Q. Can you see well?
A. I can see well, when the water is anyway clear, but this water is not clear. We can't see any more than about a foot or eighteen inches out from you.

On the fifth day of the investigation there was

Q. I have heard that on Tuesday morning you overheard a certain conversation in a ferryboat which referred to the possible sinking of the *Maine*. Will you please state to the court all you can in regard to that matter?

The INTERPRETER. At about half-past 7 on the morning of the 15th, he was crossing from Havana to Reglas. He was sitting on a front seat in the bow of the vessel—the ferryboat. There were, about 4 feet distant, three officers, two of the army and one of the navy, of Spain, and besides a citizen, a stout man, about fifty years of age. They were conversing about the *Maine*. He says one of the army officers said that in the circulio militario, the military club here on the Prado, "That is nearly arranged." The citizen inquired: "Will not making explosions in the bay run great risk to the city of Havana?" The citizen inquired that from the Spanish officer who had made the first remark. He says that the officer replied "no;" that it was arranged so that it would simply explode, open the vessel, and she would sink immediately. Then the other man, with an exclamation apparently of joy, said: "I will take plenty of beer on that occasion." At that moment a cartman came forward and one of the men touched the other and stopped the conversation, and then he could not hear any more. He said they kept on speaking, but he did not hear any more.

Q. What was the first remark made by the army officer?

The INTERPRETER. That he had heard in the circulio militario that the plans were all arranged, and they were going to blow her up anyhow; that it was a shame to Spain that she should be here in the bay. The lieutenant said: "Then if you blow her up, there would be another one come," and the superior officer said: "They would take care not to send another."

Q. Did the second army officer make any other remark?

The INTERPRETER. He says yes; they were all speaking, but they were speaking in a low voice; he could not catch all they said. He was standing up, close to the wall, so that they would not notice he was listening to them.

Q. Could you distinguish what the navy officer said?

The INTERPRETER. No; he could not.

Q. What was the character of the uniform of the army officers?

The INTERPRETER. One was a lieutenant, and the other one had stars down below the stripes. He had two stripes, which would indicate that he was from a major upward. He also had a belt—that would indicate that he is of the general's staff.

As bearing on the credibility of the witness, the following replies are of interest:

Q. Are you a married man?

The INTERPRETER. No, sir; single.

Q. Have you any family here?

The INTERPRETER. He says he and his father are here, and he has been living eighteen years with a woman, but he is not married to her.

On the sixth day a translation of the anonymous letter received at the United States Consulate in Havana was read to the court thus:

It should be remembered that at dawn of the day of the terrible catastrophe an individual was killed in a small boat, together with another, who is to be found wounded and a prisoner. They were going about the cruisers *Maine* and *Alfonso XII*, and as the said individuals are the worst antecedents as harbor thieves, I have interested myself in investigating what connection this occurrence could have with the explosion of the *Maine*, and I have discovered that those two men, together with another, who is called Pepe Taco, had bought in a harware store in Mercaderes street, called La Marina, a hose such as is used by divers, and that the three left Regla in a small boat, which they placed under the wharves of Sta. Catalina, and they were loitering more than an hour and a half, while Pepe Taco, who is a calker and diver, probably the best in these parts, did the work to bring about the explosion of the *Maine*. With this data I went to Regla and discovered that the family of the dead man, who lived in the utmost misery in a house in Rodriguez Batista street, had moved to a well-furnished one in Gelabert street. There I learned that they had agreed with some merchants of Muralla street for the work of blowing up the ship for the sum of $6,000—$2,000 in advance, the other $4,000 after seeing the result. But as they did not come out of the adventure very well, having been attacked when they were retiring, the result of which was the death of one, who left his teeth in the boat, and another one wounded, the third one has not presented himself to collect the rest of the money, and it could probably be secretly done that, by paying him the rest that the others will not now pay him, he would declare the truth of all this. The one whom I call the third is the diver Pepe Taco, who was unwounded, who no doubt is afraid to present himself to collect the rest. In Muralla street they tell me was the place where the business was arranged with Messrs. Garcia Corujedo, Villasuso, Maribona, and others, whom I do not remember. The man arrested is being administered morphine constantly to see if he will die and not give evidence, so as not, as they express it, to spoil the affair after it has come off so much to their taste.

HAVANA, Feb. 11, 1898.

When the letter was read the court made inquiry as to whether any effort had been made to ascertain the truth of the information contained in the letter. A clerk in the Consulate said that General Lee had informed him there was no secret service money available for such an investigation.

Captain Sigsbee, recalled, was questioned:

Q. You are quite certain that no torpedo warhead was fitted to a torpedo on board the *Maine* the day of the explosion?

A. I am certain I gave no order to fit them, and it was well known to the executive officer that I did not intend to fit them.

Q. Did you enter the harbor of Havana with a torpedo warhead fixed?

A. No.

Q. Did you, at any time subsequent to your entry of the harbor, have the warheads on any of the torpedoes?

A. The warheads have not been disturbed in any respect since I have had command of the ship.

Lieutenant Commander Richard Wainwright, recalled, gave corroborative evidence:

Q. Were you on board the whole day on the evening of which the explosion occurred?

A. Yes, sir.

Q. Are you certain that no warheads were fitted to the torpedoes of the *Maine* on that day.

A. I am positive of it. It could not have been done without my seeing it. I knew what work was going on on the torpedoes, always. I took a special interest in them and consulted frequently with the officer in charge of the division. The Captain has ordered us not to put the warheads on. I mentioned the subject of the warheads to the commanding officer at least twice, and both times he told me not to do so.

Q. As you were on board the *Maine* during her last stay in Havana, and were frequently on deck, did it ever occur to you that the ship was almost always swinging in any certain direction?

A. A large portion of the time the wind was to the eastward, and we always swung to the wind, generally a little to the southward of east, as I remember now, though I am not positive about the points of the compass. We generally pointed to the eastern shore.

HIGH PRESSURES AT SEA WITH SOME CONSIDERATION OF TYPES OF BOILERS.*—III.

BY W. R. CUMMINS.

Fourth—Sufficient time should be given to allow the gases to give up the desired amount of their heat before they pass away to the uptake.

Fifth—There should be a sufficiently large body of water over the highest heating surface to allow the boiler to run some time with the feed shut off.

Sixth—Every part of the boiler, both inside and out, should be accessible for examination, cleaning, and repairs, and every part exposed to the heat of the furnace, or hot gases should be renewable without interfering with the main structure of the boiler, also all tubes should be straight, of fairly large diameter, and of the same length.

Seventh—The lower part of the boiler should be so arranged that if any mud or grease collects there it can do no harm by causing overheating.

Eighth—The circulation of water should be active and natural.

Finally—The cost of construction and the space occupied should not be more, and if possible should be less, than the present return-tube boiler.

As regards the first point, viz., the thickness of the material forming the heating surface, this is a most important point, as the increased temperature of the water will decrease the efficiency of the heating surface, and if, in addition, the plates have to be made thicker for the increased pressure, we shall still further decrease the efficiency. For instance, the thickness of circular furnaces would be increased for the higher pressure, unless the diameter were decreased. The thickness of the plates forming flat stayed surfaces would also need to be increased, the alternative being to decrease the pitch of the stays. The thickness of plain tubes would not need to be increased to any appreciable extent, but stay tubes would need to be thicker or closer pitched. Hence, to satisfy this first condition, preference should be given to a boiler in which the greater part of the heating surface consists of plain tubes.

As regards the second point, viz., the size and disposition of the combustion chamber, this has a well-known bearing on fuel economy. It is of the utmost importance to have a large combustion chamber, where the furnace gases may combine before they part with their heat, and where unconsumed gases may have room to pick up more oxygen or more heat, as, if their temperature is not raised to the combining temperature, they will pass away to the funnel unburnt, entailing a serious loss of heat. The ideal combustion chamber would be a large free space directly over the furnace.

As regards the third and fourth points, viz., the distribution of the gases over the heating surfaces and the time they remain in contact with the latter, this affects the efficiency of the heating surface to a large extent. To effect a given coal economy the heating surface must abstract a given amount of heat from the gases. To do this we must not only have the right extent of surface, but we must also have it so disposed as

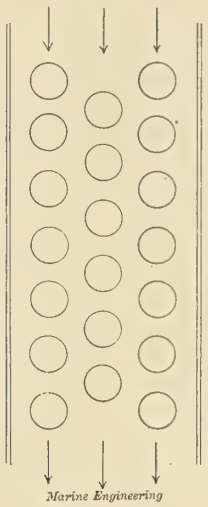


Fig. 3

to split up the gases and allow them time to give up their heat. Of course the efficiency of the heating surface will also depend upon the circulation on the water side, but that point will be touched on later. The accompanying sketch illustrates the point as to the time the gases take to travel over the heating surface. Fig. 2 represents an arrangement of 2 1-2 in. water tubes, say 2 ft. long, with the hot gases passing in the direction of the arrows. Fig. 3 shows the same tubes arranged so that the gases pass in the other direction. The area for the passage of the gases is the same in both cases; hence the velocity of the latter will be the same; but with the tubes arranged as in Fig. 3 the gases will take more than twice the

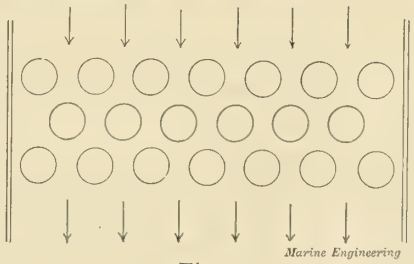


Fig. 2

time to traverse the heating surface than when arranged as in Fig. 2. Now, it might be that the time occupied in Fig. 2 would not be sufficient to extract the desired quantity of heat from the gases, and this would place the arrangement at a distinct disadvantage, although it has the same heating surface as Fig. 3. Hence, preference

*From a paper read at the North-East Coast Institute of Engineers and Shipbuilders in Sunderland, England.

should be given to a boiler which splits up the gases, leaving the combustion chamber, into small streams, and compels them to travel some considerable distance in contact with the heating surface before they pass away to the uptake.

As regards the fifth point, viz., the amount of water over the highest heating surface, the weight of water should be such as to allow the engines to run some little time with the feed shut off, as it will contribute a great deal to the comfort and peace of mind of the engineer if he knows that in case of a failure of the feed pumps he can run the engines some little time without burning the boiler.

As regards the sixth point, viz., accessibility for cleaning and repairs, and facilities for renewing damaged or defective parts, this is perhaps the most important point affecting the good working of the boiler. Absolute cleanliness of the heating surface is a necessity even for 150 lb. pressure, and in spite of feed filters and evaporators a certain amount of sediment and scale will find its way into a boiler so that it is very necessary to have every facility for cleaning. It is also very desirable that all parts of the boiler exposed to the heat of the furnace gases should be arranged to be conveniently renewed. All boilers are arranged to allow of re-tubing, but very few are arranged to allow of new furnaces being fitted, and in most cases a new combustion chamber means a new boiler. It is also desirable that the boiler should be arranged to allow of re-caulking all over, both inside and outside. All tubes should be straight, or nearly straight, and of the same length, otherwise a great number of spare tubes must be carried. They should also be of fairly large diameter, say not less than 2 in. This permits them to be examined from end to end.

As regards the seventh point, viz., provision at the bottom of the boiler of a quiet place where mud and grease may collect, a certain amount of mud and grease will get into a boiler, and it is well known that this is the most fruitful cause of collapsed furnaces. Hence, surfaces at the bottom of the boiler where grease could lodge should not, if possible, be exposed to heat.

As regards the eighth point, viz., the water circulation, this affects not only the good working of the boiler, but also the efficiency of the heating surface. In the first place, the circulation should be natural—*i. e.*, there should be no necessity for a pump or hydrokineter or other complications to compel the water to circulate. A free and natural circulation is especially valuable when raising steam, so that the whole of the water in the boiler may be practically the same temperature, and thus avoid racking strains on the boiler through unequal expansion. A good circulation on the water side of a heating surface is just as essential, and perhaps more efficient than a good circulation of the gases on the fire side. The most effective combination would be a moderate velocity of the gases and a great velocity of the water, and the water and gases moving in opposite directions. The best means of securing a maximum velocity of the water will be by vertical water tubes, as the entraining action of the steam bubbles will have free play.

As regards the final and most important point, that of cost, it was pointed out in the foregoing that, with 250 lb. pressure, under the most favorable conditions and with machinery costing not more than the present triple-expansion machinery, the saving in expenses on a boat of the size there specified would be 6 1-2 per cent. Whether this would be a good speculation remains to be discussed, but at any rate the engineer's choice of a boiler for 250 lb. pressure should be largely influenced by its cost of manufacture.

We can now proceed to discuss the merits of the various types of boilers.

Take first the ordinary cylindrical return-tube boiler. That it is capable of being worked at 250 lbs. pressure has already been demonstrated in the case of the screw steamer Inchmona. For this pressure, however, it is absolutely necessary to keep the diameter of the furnace as small as possible, hence some system of assisted draught is a necessity in order to burn the requisite amount of coal. The thickness of the material composing the heating surface will be considerably increased over the thickness required for 150 lbs. pressure, namely, the furnaces. by about 25 per cent, the fire-boxes and tube plates by about 10 per cent, and the stay tubes by about 50 per cent. To estimate the combined effect of all these different increases of thickness, as well as the effect due to the increase of temperature of the water, it is assumed that for the furnace and fire-box heating surface the heat transmission varies as the square root of the thickness of plate, and that the increase of thickness of the stay tubes has no appreciable effect upon the heat transmission.

The temperature in the furnace may be taken at 2,500 deg. Fah., in the firebox at 1,800 deg. Fah., and the mean temperature in the tubes at 1,250 deg. Fah.

Then for the furnaces we have,

$$\frac{(2500-366)^2}{(2500-406)^2}\times\sqrt{1.25}=1.16,$$

i. e., 16 per cent. less efficiency than under the lower pressure conditions.

For the fireboxes,

$$\frac{(1800-366)^2}{(1800-406)^2}\times\sqrt{1.10}=1.10,$$

i. e., 10 per cent. less efficiency than under the lower pressure conditions.

For the tubes,

$$\frac{(1250-366)^2}{(1250-406)^2}=1.09,$$

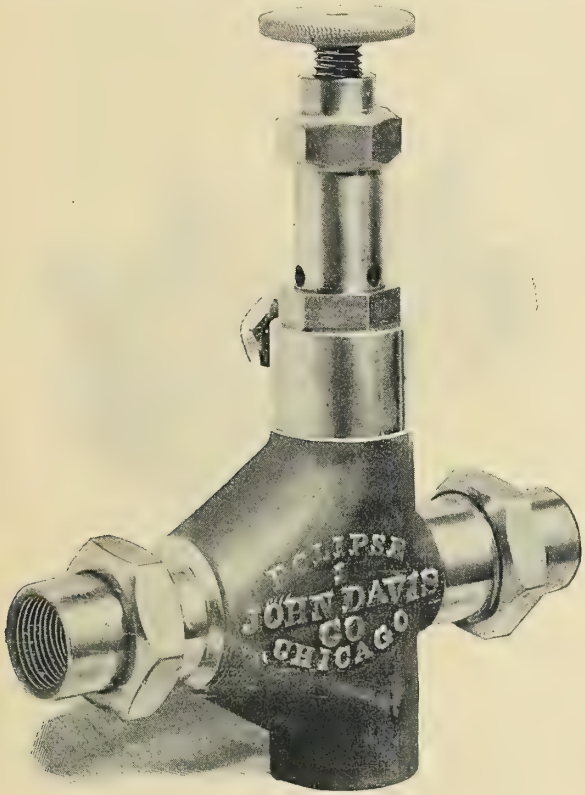
i. e., 9 per cent. less efficiency than under the low pressure conditions.

(*To be continued.*)

IMPROVED APPARATUS.

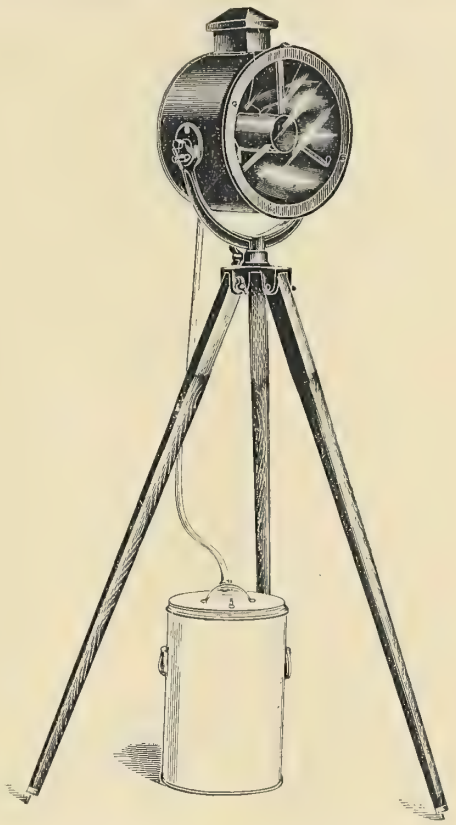
Acetylene Gas Searchlight for Small Boats.

The convenience of a searchlight is well recognized by those who have occasion to be under way at night. In making landings, in picking up buoys, in running up narrow channels or even in sailing close to the shore, it is indispensable. On small boats, however, owing to the lack of necessary apparatus for supplying current, it has hitherto been impossible to enjoy these benefits. Acetylene gas has now made possible the use of a searchlight in vessels unprovided with electrical apparatus. A light of sufficient intensity to illuminate objects within a radius of 600 feet is shown in the accompanying illustration. Here the searchlight is mounted on a light wooden tripod such as would be used by contractors or for railway purposes, work on fortifications and in mines, lighting lawns, etc., but it can be lashed to an eyebolt on deck. A special mounting is used on boats having a pilot house, so that the motion can be communicated to the light by the steersman inside the pilot house. One generator only is required for several searchlights if near together. The generator consists of two cylinders of proper proportions one within the other. The tank or outside cylinder is perfectly



ECLIPSE REDUCING VALVE.

plain; the gas-holder or inner cylinder is free to move within the tank, and in the top carries the carbide basket, which is introduced from underneath, and thus obviates the necessity of clamps or screw caps, which are always liable to leak. The condenser, of extra large surface for drying the gas, is at the lower part of the gas-holder. An outlet with "stop-cock" is provided for the gas. The overflow pipe prevents the gas from bubbling under the gas-holder, and consequent splashing of water on the floor. The gas-holder



AUTOMATIC ACETYLENE GENERATOR AND LIGHT.

is so arranged that the carbide is automatically raised out of or lowered into the water when the supply of gas is increased or diminished, and the pressure never rises over one or two ounces to the square inch. The generator will also light several lights in the cabin if desired at a cost of running, the makers state, of about one cent per hour. The searchlight and generator is manufactured by J. B. Colt & Co., 3, 5, and 7 West 29th street, New York.

Eclipse Steam Reducing Valve.

A new compact form of reducing valve for marine work, here illustrated, has been put on the market by the John Davis Co., of Chicago, and styled the "Eclipse." As will be seen by reference to the diagram there is no chance of rupture of a diaphragm, for it hasn't any, and there is also no stuffing box needing attention. The valve consists practically of one working part, which when set, will maintain a constant pressure in the flow irrespective of any rise in pressure in the supply pipe. The spring is entirely out of the steam, and consequently, when at work, is at a lower temperature than is likely to affect its temper. The address of the manufacturer is 51 Michigan St., Chicago.

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LAST month we published a list of the vessels of the Spanish Navy "brought down to date," and soon thereafter Admiral Dewey unceremoniously made it out of date. Courage, seamanship and gunnery skill won a glorious victory at Manila, and in seamanship we include the whole range of effort afloat, from the guiding mind on the bridge of the flagship Olympia to the least noticed passer in the darkest bunker in the fleet. Admiral Dewey commanded, the others obeyed, and so the fight was won. To bring our list up to date we might write across the names of these ships; sunk by American fire: Steel protected cruiser, *Isla de Cuba;* unarmored iron cruisers *Don Antonio de Ulloa* and *Velasco*, unarmored iron gunboats *General Lezo* and *Marques del Duero*, wooden cruiser *Castilla*, auxiliary cruiser *Isla de Mindanao*, the *Correo*, probably a small gunboat, and an unnamed transport. Besides engaging these vessels Admiral Dewey bombarded the fortifications at Cavite with the most extraordinary result of having no men killed or wounded in his fleet.

FOLLOWING the passage of the Naval Appropriation Bill there is evidence of a desire on the part of the Navy Department to promptly put into effect its provisions. The bill, as our readers will recollect, provides for the construction of three sea-going coast-line battle ships, four harbor-defense monitors, sixteen torpedo-boat destroyers and twelve torpedo boats, and also one gunboat to replace the "Michigan" on the Great Lakes. A circular has been issued by Secretary Long, for the information of intending bidders, defining the chief characteristics of the sixteen torpedo-boat destroyers and the twelve torpedo boats. This informs ship and engine builders that they are at liberty to prepare their own plans of hull and machinery to fit the general requirements of the vessels. They can, however, if they prefer, follow the plans and specifications of the Department or embody any part of these in their own designs. This latitude, which has previously been allowed by the Navy Department in the details of design and construction of high-speed boats, is very commendable. It is a recognition of the science, which is to be found in many yards, and experience which might dictate methods of obtaining results other than those adopted by the naval designers. But if originality is allowed in design, there are very rigid regulations regarding performance. Considering these, and the difficulties attendant upon the successful construction of, what are now considered, extremely high-speed vessels it will be well for bidders to carefully consider their facilities before competing. The general features of the two classes of vessels may be interestingly noted. The torpedo-boat destroyers are to have a displacement on trial between 400 and 435 tons, and to attain a speed of not less than 28 knots on two hours' trial. If on this trial the speed falls below the speed guaranteed by the bidders, the boat may be accepted at a reduction in price, at the rate of $8,000 for each quarter of a knot. Should the speed fall below 28 knots the vessel will be rejected. The destroyers will have twin-screws, water-tube boilers and bunker capacity for 100 tons of coal, which will be placed so as to give protection to the machinery. Each is to have two conning towers, the forward one to be of half-inch nickel steel plates. The battery, which will be provided by the Government and put in position by the contractor, will be composed of seven rapid-fire guns, the ammunition for which will weigh about seven tons. There will be fitted, also, two twenty-foot torpedo tubes on the midship line, and space below for stowing two spare torpedoes and four war heads. The berthing space will give accommodation for a crew of sixty men and four officers, with provision space for twenty days' supply. Lighting will be by electricity throughout, and a search light will be part of the equipment. The weights

to be carried on trial in addition to completed hull and machinery, with spare parts and fresh water necessary for trial, will be, in long tons: Ordnance, 15 tons; coal, 25 tons; crew, stores and equipments, 12 tons; or a total of 52 tons. The law provides that not more than five destroyers and not more than four torpedo boats shall be constructed in any one yard, or by one contracting party. In the regulations just issued the cost of destroyers may not average more than $295,000 each in any bid. This gives a maximum cost of about $702 a ton for the vessels completed. This is rather lower than the average of bids for the three destroyers contracted for by the Government last summer, which was in the neighborhood of $750 a ton. The twelve torpedo boats are to be within the limits of 150 to 170 tons trial displacement. They will also have twin-screws and water-tube boilers and bunker capacity for forty tons of coal. They are each to have two conning towers, the forward one of half-inch nickel steel. The battery of each boat will be composed of three rapid-firing guns, with about three and a half tons of ammunition, and on deck each will carry three fifteen-foot torpedo tubes. Stowage space will be provided for two additional torpedoes and five war heads. There will be a complete electric lighting plant on each boat, including a search light. There will be a berthing space for a crew of twenty-six men and three officers and provision space for twenty days' supply. The trial weights in addition to the hull and machinery ready for sea will include: Ordnance, 9 tons; coal, 10 tons; crew, stores and equipments, 8 tons; or a total of 37 tons. A minimum trial speed of 25 knots is demanded, or, should the boat fail to reach the speed guaranteed by the bidder, a penalty of $8,000 for each quarter knot will be exacted. In considering the bids submitted, the Department will give preference, other things being equal, to such designs as are best suited for the United States Naval Service, and among the matters of importance to be considered in this connection, according to the circular issued, are:

The highest practicable speed guaranteed.

Designs showing the best seagoing qualities and giving the best protection to engines and boilers.

Shortest time within which bidders will guarantee completion of vessels.

Plans and specifications are now being prepared by the Navy Department, and it will necessarily be some time before these are ready for bidders. When the plans and specifications are issued bidders will have three weeks in which to prepare their estimates and submit bids. All bids must state the date of completion of the vessels, and the maximum time limit is placed at eighteen months for destroyers and twelve months for boats. The Scotch price for the Spanish 400-ton destroyers was about $460,000 each.

CONSIDERING these new naval plans we are reminded that in some yards there is a disposition to sneer at "science" and exalt "practical experience." In the building of scows, harbor tugs, ferryboats, of what might be called the Colonial pattern and similar craft, science is probably a luxury, and luxuries don't go in the average shipyard. When a man has only to look up hull plans that his grandfather drew, and fish out engine patterns made during the Civil War, to fill his order, he doesn't need to bother with metacenter and stream lines, ratios of expansion and cavitation. Practical experience in throwing together the hull and machinery, running a trial trip, and getting his pay, is the need of this builder. Frequently, however, there is a buyer who wants an up-to-date vessel, and Uncle Sam is very choice in this respect. He will soon contract for as crack a lot of boats as ever kept a shipyard busy since Noah built the Ark. There is not a builder in the country, and mighty few out of it, who ever launched a 400-ton 28-knot boat. Where does the practical-experience man stand now? His practice does not extend to such vessels and his experience covers nothing of the kind. If he is wise he will admit to himself his need of the despised science, for science is experience ready made. It has no fight with practice, but simply supplements the art. Practice laughed at Froude and his duck pond, while today our Government is spending thousands of dollars on an experimental tank. Science is sometimes self-complacent and gives reason for experience to find fault. Science, not long ago, devised a method of balancing engines which works out beautifully in smooth water and atrociously in a seaway. Science needs art for ballast. The lack of a knot in the contract speed of one of the new destroyers represents $32,000, and though science comes high, this would buy a lot of it. The practical builder would do well to remember this, and also that science is modest and has to be sought, though there is lots of it between Fire Island and Point Reyes.

CORRESPONDENCE.

[Communications on matters of interest to marine engineers, for insertion in the correspondence department, are solicited. These, wherever possible, should be supplemented by rough sketches or drawings, which will be reproduced if necessary to illustrate the subject without cost to the writer.

Full names and addresses should be given, but publication of these will be withheld where requested.

We do not assume responsibility for the opinions expressed by correspondents.]

Reply to Inquiry About H. P. Diagrams.

In reply to the query of "Potomac" relative to his high pressure indicator diagrams, I send a sketch and table and a valve diagram. As to the data he gives,

STROKE 28″
TRAVEL OF VALVE=5¼″

	PRESENT		PROPOSED	
	TOP	BOTTOM	TOP	BOTTOM
LEAD	1/16″	1/16″	1/4″	11/32″
STEAM LAP	1 9/16″ f	1 9/16″ f	1 1/2″ f	1 7/16″ sc
EXHAUST LAP	0	3/8″	0	3/8″
CUT OFF	18 3/4″	16″	18 1/4″	16 1/2″
RELEASE	25 7/16″	25 9/16″	25″	24 7/16″
COMPRESSION	3 5/8″	3 5/8″	4 3/8″	4 1/8″

Marine Engineering

I believe the figure "2 inches" for the cut-off is certainly a mistake. The figure for the lead, viz., 1-16 inch top and bottom explains the whole difficulty with the diagram. At 102 revolutions, for an engine of this size, this amount of lead is entirely too small, and no amount of raising or lowering the valve is going to help matters. The only way to correct the difficulty is to shift the eccentric sheave of the Stephenson link motion. Assuming that the indicator gear was properly adjusted and that the card was carefully taken, the following Zeuner's diagram (Fig. 1) may be deduced from the card and the data given. This diagram shows that the steam opening does not take place until the crank is almost on the dead center. The dotted lines of the proposed setting show a lead of 1-4 inch on top and 11-32 inch on the bottom which is about right for that size of engine. Assuming that the distance between centers of the connecting rod is about 64 inches, the table shows the results deduced from the diagram. The proposed average cut-off remains the same as before, the release will be a trifle earlier, which is a decided advantage in a triple expansion engine, and the compression will be increased slightly, which will also be of advantage. The eccentric must be shifted back an amount equal to the angle P O R, which can easily be done by making an offset key. As the valve takes steam in the center, the eccentric follows the crank. At present the angle between the eccentric and the crank is P O N, and this must be reduced to R O N, also a small amount taken off of both steam laps of the valve as shown in sketch. (Fig. 2.)

It is very probable that the valve is fitted

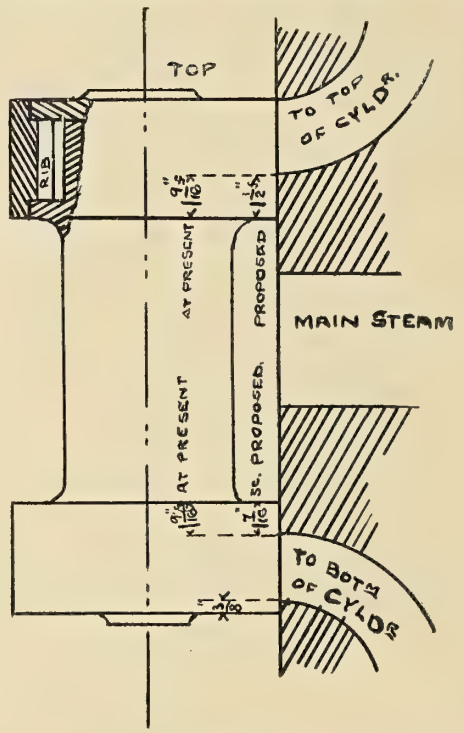


FIG. 2.

with spring rings, and that the cutting off edges are not sharply defined. These spring rings have long been abandoned on piston valves, as they have a tendency to wear the valve chamber out of round. Valves of this kind are usually altered as

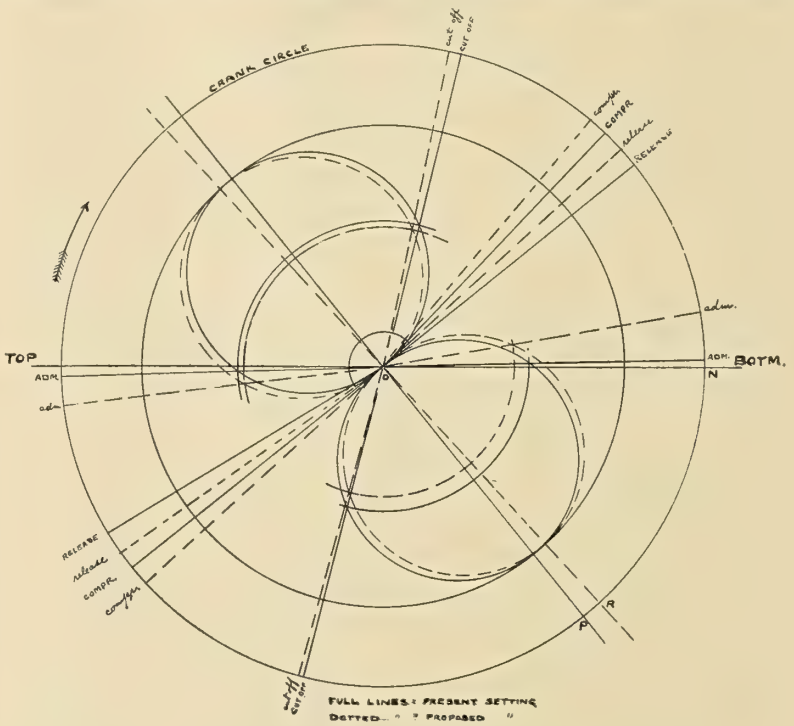


FIG. 1.

shown in sketch (Fig. 2). The cut-off lip on the valve and follower are turned off and a solid ring, with eight or ten ribs on the inner side, is put on with its edges overlapping, as shown, making a sharply defined cut-off edge. The follower holds the ring in place, allowing a slight side motion for adjustment if the valve stem gets out of center. If this type of ring is carefully fitted to a true chamber so that it will just jam when a narrow strip of one thickness of tissue paper is introduced with it at one side, the valve will run easy, and be steam tight for at least six years of steady service. H. L. EBSEN.

Replying to "Potomac," the diagrams show the valve has not sufficient lead. Again it may be possible that the valve gear is not as rigid as it should be, and when the engine is pinched over the centers, the valve shows, as he says, 1-16 in. lead, but when running at full speed the friction of the valve and gearing may cause it to be a little later each way, so that at such times there may be a little negative lead. Possibly the trouble may be caused by long and tortuous indicator connections.

If the valve gearing is the link motion with two eccentrics they can be set ahead a little, thus increasing the lead and at the same time give the needed improvement in compression.

The cut off must be 12 in. instead of 2 in., this evidently being a mistake.

SAM'L T. WILLIAMS.

A Query and Reply Concerning Estimated Weights.

The formulæ for estimating weights of machinery, by Professor G. R. McDermott, published in the February issue, are very interesting and instructive and would have been much more so had the pressure been taken into consideration. It is quite evident that two boilers of the same general dimensions, one constructed for a pressure of 100 pounds per square inch, and the other for 200 pounds per square inch, the one for the higher pressure must necessarily be much heavier than the other. The same thing is true with the engine. H. J. TEIPER.

REPLY.

Replying to Mr. Teiper, I beg to refer him to the remainder of my paper as read at the Society of Naval Architects and Marine Engineers in which I stated that, "The formulæ have been built up on current practice, triple expansion engines and boiler pressures from 150 pounds to 175 pounds. It is interesting to note, however, that they give a close approximation to the weight of compound engines, and pressures of 80 pounds to 100 pounds." Further on it is stated, "Unfortunately, sufficient data is not at hand of quadruple engines to allow of definite statements being made as to the probable increase in weight, but in a general way an increase of about 5 per cent. should be made on the engine room and boiler room weights as estimated by formulæ.' '

Apart from the above I may remind your correspondent that the weight obtained by use of formulæ, for both engine and boiler room weights, include a large number of items which are not affected by differences in boiler pressures. In seeking for a general formulæ I found, after repeated trials, that a representation of boiler pressure did not give any more accurate results, in fact there were greater differences observed between the weights of similar machinery built by different makers than existed between engines and boilers with a difference of pressures within the limits of 80 pounds to 250 pounds. I agree with Mr. Teiper in so far that in any formulæ for weights of separate items, such as boiler shell, cylinders, etc., pressure would demand attention, but its introduction into the general formulæ only renders it all the more complicated without yielding any more satisfactory results. GEORGE R. MCDERMOTT.

[The remainder of the paper, as referred to above by Professor McDermott, will be found, commencing on, page 20 of this issue.—ED.]

EDUCATIONAL.

ELECTRICITY ON BOARD SHIP, PRINCIPLES AND PRACTICE.—IX.

BY WM. BAXTER, JR.

Generators of the two pole type, such as described in the last three articles, are seldom used, except for small sizes, owing, mainly, to the fact that their output per pound of weight, or per unit of linear dimensions, is less than that of those constructed upon the multipolar principle. In the early days of the electrical industry, the two pole type became the favorite on account of its greater constructive simplicity, but when a demand for generators of several hundred horse power capacity began, the evident superiority of the multipolar machines won for them their well merited recognition.

The principles involved in the operation of two pole and multipolar, generators are the same, and the advantage of the latter consists in that a greater amount of work can be done by a machine of the same size; but it must not be inferred from this that the result can be obtained without increasing the size of the steam engine required to drive the generator. A two pole machine of high efficiency will transform into electric energy ninety per cent. of the power required to drive it, and a multipolar generator will not do any more. The advantage, therefore, is that if you have a combined engine and generator to do a certain amount of work, the total weight of the combination will be less if the generator is of the multipolar type, and in most cases the space occupied will be reduced. Why a multipolar generator can be made lighter than a two pole machine can be made clear by the aid of Figs. 46, 47 and 48, which are diagrammatic representations of a two pole, a four pole and an eight pole machine. In the four pole diagram, Fig 47, it will be noticed that the N and S poles alternate around the circle, and the same order is maintained in the eight pole type, Fig. 48. It will also be seen that so far as the field magnets alone are concerned, two adjoining poles with the portion of the outer rim that connects them form a complete magnet. Thus in Fig. 47 the top and the left hand poles constitute a complete magnet, and so do the top and the right hand pole; in fact, if we were to divide the machine along either one of the diagonal lines d d, or e e, we would have two complete fields, each one provided with one-half of an armature. If we bent the half armature around into a complete ring and stretched the rim b, connecting the poles, so as to bring them opposite each other, then we would have two complete two pole machines. By pursuing the same course with the eight pole diagram, Fig. 48, we could obtain from it four two pole machines. We may, therefore, regard any multipolar machine as made up of a number of two pole generators placed around the circle, with the armatures cut on one side and spread out so as to form parts of a larger ring. From this explanation of the principles involved in the construction of multipolar machines, we can also see that there are as many separate paths for the lines of force, or magnetic circuits, as there are poles, and that these pass through a smaller portion of the machine as the number of poles is increased, and therefore are shorter, as is clearly indicated by the line f in the three figures. Now the amount of wire required for the magnet coils will decrease as the length of the magnetic circuits is decreased, so that for Fig. 47 less wire will be required than for Fig. 46 and for Fig. 48 still less than for Fig. 47. The three figures are drawn to the same scale, and represent machines of the same capacity; therefore, the relative sizes and weights can be judged by a comparison of the proportions of the corresponding parts. The line f in Fig. 46 is about twice as long as in Fig. 47 and about four times as

long as in Fig. 48, hence the length of the iron part of the magnetic circuits in the three machines is nearly in the proportion of 1, 2, 4. But the air gap, that is the distance between the face of the pole and the surface of the armature core, is not reduced in the same proportion. It is in Fig. 47 more than one-half as much as in Fig. 46 and in Fig 48 more than one-fourth as much as in Fig. 46. The actual number of turns of wire in the coils of the three machines therefore will be about as indicated by the areas inclosed by their outlines. The diameter of the armatures and the width of their faces is the same in the three figures; therefore, it will be seen that although there are more than half as many turns of wire in each coil of Fig. 47 than in the coils of Fig. 46 the length of each turn is less, owing to the fact that the width a of the core is twice as great in Fig. 46 as in Fig. 47, hence the total length of wire in the two coils is more nearly in the proportion of 2 to 1 than would appear from the cross section alone.

As the armatures are of the same diameter, the number of turns of wire wound upon each will be the same, and if the velocity of rotation is the same the

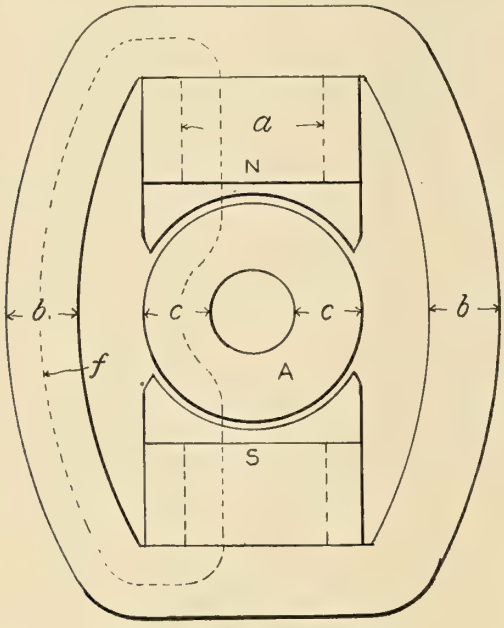


Fig. 46.

electro motive force developed will be in proportion to the number of lines of force in the magnetic circuits, and this number will be directly in proportion to the cross section of the magnets. In Fig. 46 the width c of each side of the armature core is equal to one-half of the width a of the magnet core, and as one-half of the lines of force pass around each side of the magnet frame, the sides are of a width b equal to one half of a, so that c and b are of the same section. In Fig. 47 a is equal to one-half of a in Fig. 46, and b and c are also equal to one-half of b and c in Fig. 46. Hence, the number of lines of force that will pass through each one of the magnetic circuits in Fig. 47 will be one-half as great as in each of the circuits in Fig. 46. In the latter figure there are two magnetic circuits, while in Fig. 47 there are four, from which we can see, by a simple multiplication, that the total number of lines of force in the four circuits of Fig. 47 is the same as the total in the two circuits of Fig. 46.

In Fig. 48 the width a of the magnet is one-quarter as great as a in Fig. 46, and this same proportion is maintained in respect to b and c; therefore, following the same line of reasoning as in connection with Fig. 47. we will find that in each one of the magnetic circuits of this figure the number of lines of force will be one-quarter of those in the magnetic circuits of Fig. 46, but as there are eight circuits instead of two, the sum total will be the same just as in Fig. 47.

From the foregoing we see that if the number of poles is doubled the number of lines of force passing through each pole can be reduced to one-half to main-

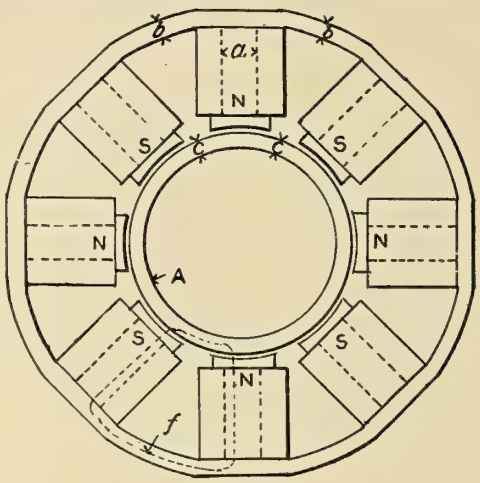


Fig. 48.

tain the same total number of lines in the entire machine. As the number of turns of wire on the armature remain the same, the electro motive force developed by the action of each pole will be directly in proportion to the number of lines of force passing through it; that is in Fig. 47 it will be one-half as great as in Fig. 46 and in Fig. 48 one-fourth. As the number of poles, however, acting in Fig. 47 is twice as great their combined effect will be the same as that obtained in Fig. 46 and in the same way the combined effect of Fig. 48 will be also equal to that of Fig. 46, because there are four times as many poles.

The wire on the armatures of Figs. 47 and 48 can be connected with the external circuit so as to develop the same voltage and same strength of current

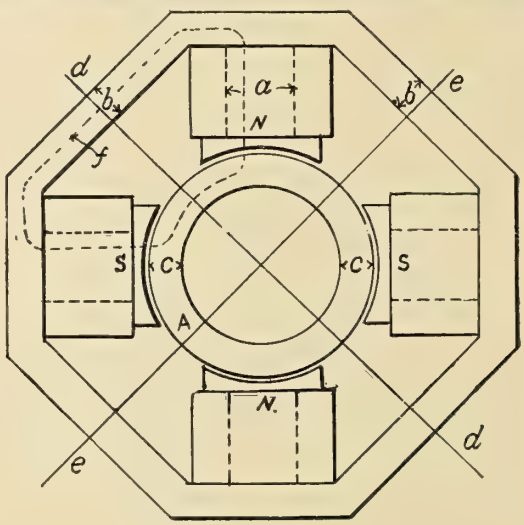


Fig. 47.

as is obtained from Fig. 46; or from Fig. 47 we can get one-half the voltage and twice the current strength, and from Fig. 48 one-quarter the voltage and four times the current strength. But whatever the combination may be, the energy of the current in

the three cases will be the same, and the relative sizes and weights of the machines will be in direct proportion to the difference shown by the proportions of the three diagrams.

From this explanation it will be seen that the greater the number of poles the smaller and lighter the machine for a given capacity, and if it were not for the fact that as the number of poles is increased certain mechanical and electrical difficulties begin to appear and grow with remarkable rapidity, it would be possible to obtain an enormous output from a very small generator by simply increasing the poles to a suitable number. One of the difficulties that is most easily understood is that in order to prevent sparking at the commutator it is necessary to have a large number of segments between each pair of brushes, and as the number of brushes is equal to the number of poles, the diameter of the commutator is increased as the number of poles is increased, and when this diameter becomes nearly equal to that of the armature, the limit is reached. It might be said that we could get around this difficulty by reducing the width of each commutator segment, but we cannot reduce it below a certain point because it must be wide enough to receive the end of the wire from the armature coil.

It will be noticed that if the cross sections at a, b and c of the field magnet and the armature are reduced in the proportion of 1, 2 and 4 the amount of wire required for the magnet coils will increase slightly as the number of poles is increased. This would not be desirable, as it would not only mean a greater expenditure for wire, but also a greater amount of electrical energy used in developing the magnetic field, and thus a decreased electrical efficiency. This difficulty is overcome, however, by leaving the amount of wire the same in each case, and increasing slightly the cross section of the iron to compensate for the reduction in magnetic density. If we desire to sacrifice the efficiency to obtain lightness, the iron cross section can be made in the ratio of 1, 2, 4, but if we desire to maintain the same degree of efficiency, the magnet coils are made so that the length of wire in each one decreases in the ratio of 1, 2, 4, and the reduction in field strength is made up by a slight increase in the weight of the iron parts.

The advantages derivable from the adoption of a multipolar construction can be utilized either to reduce the weight of the machine or its velocity, or a midway course can be adopted and the gain be divided between reduction in weight and in speed. Two pole generators run, generally, at velocities ranging from about 700 revolutions per minute, for the largest sizes, to 2,000 and even more in small machines. Multipolar generators, however, are run at speeds between 1,000 and 100, or even less. These machines are driven either by means of a belt or by being connected directly to the shaft of a steam engine. When of the belt type the speed may range from about 500 for large sizes to 1,000 for the smallest; but when directly connected with a steam engine the velocity is controlled by the speed at which the engine can run safely. Generators that require from 50 to 200 horse power are connected with high speed engines that run at a speed ranging from 200 to 300 revolutions per minute. If the power is greater than 200 or 300 horse power, the revolutions will be below 200, dropping as low as 80 or 100 for generators that require from 1,500 to 3,000 horse power.

From the foregoing it will be seen that in small machines the gain effected by using the multipolar construction is utilized principally in reducing the weight, while in large ones it is utilized to reduce the speed of rotation. If it were not for the increased capacity of multipolar machines, per unit of weight, large generators of slow speed could not be made, and even if of such velocities as would be permissible, their dimensions as well as weight would be much greater than that of those now in use.

The general proportion of the various parts as shown in Figs. 47 and 48 are not followed in the generators actually constructed, as they are not as compact as they might be. The figures have been drawn in this skeleton fashion so as to clearly present to the eye the difference in size of machines of equal capacity, but with different number of poles. By properly condensing the design the space occupied is considerably reduced, but no additional gain is affected in the weight, and in fact in some cases the weight is actually increased a trifle. In the next article we will give an explanation of a number of the most prominent types of multipolar generators.

QUERIES AND ANSWERS.

Q. Would you kindly give the length and breadth of the hull of the "Great Eastern," and the dimensions of her engines? VACUUM GAUGE.

A.—The following particulars of the steamship Great Eastern are from the most authentic sources: She was built by Scott Russell & Co., of London, who also had the contract for the paddle engines. The contract for the screw engines was let to James Watt & Co., of Birmingham. Work was commenced on the hull early in 1854, and she was ready for launching late in 1857. The effort to launch her then was not successful, and she was not afloat until January, 1858, the expenses of launching having been about $500,000. She was built of iron, and fitted with a single screw and side wheels. Her dimensions were: Length, 692 ft.; beam, 82 ft. 6 in.; depth from main deck, 58 ft.; gross tonnage, nearly 19,000 tons; displacement at 30 ft., 30,000 tons. She was flush decked, had four decks, and a double bottom, which was carried up above the water line. The upper deck was cellular.

The propelling engines were simple, the working pressure being about 20 lbs. per sq. in. The paddle engines had four cylinders, each 74 in. dia. and 168 in. stroke, making about 25 revolutions per minute and indicating about 3,500 horse power. The screw engines were horizontal simple engines, with four cylinders 84 in. dia. and 48 in. stroke, run at about 55 revolutions and indicating about 4,500 horse power. There were ten multi-tubular double-ended square box boilers, 18 ft. long, 17 ft. 6 in. wide and 14 ft. high, with 112 furnaces in all. She burned about 300 tons of coal a day, and averaged anywhere from 13 knots to 15 knots, according to conditions. The side wheels were 56 ft. dia., and the propeller wheel 24 ft., with a pitch of 44 ft.

During her active life the Great Eastern made nearly a dozen passages across the Atlantic with passengers and cargo. Mechanically she was a great success, but commercially a failure, and she was broken up a few years ago on the beach in the Mersey, opposite Liverpool, after having passed through many ownerships.

Q.—My engine has two 5 in. by 6 in. high pressure cylinders, cuts off steam at 5-8 in. stroke, and turns 400 revs. per minute with 200 lbs. steam in the boiler. What size should cylinders of a triple-expansion engine be to be furnished with steam from the same boiler? What would be the gain in power, or, how much faster would the triple-expansion engine drive a boat 65 ft. by 8 1-2 ft.? D.

A.—Assuming that your boiler has power enough to turn your engine continuously at 400 revolutions with about 200 lbs. gauge pressure, and that the engine is of ordinary design, you are probably getting from 60 to 70 indicated horse power. If you substitute for this engine a triple-expansion condensing engine of good design, you should nearly or quite double the power on the same expenditure of steam. This would give with the same boiler capacity a power of, say, 130. Keeping revolutions the same at 400, an engine 6 in., 9 1-2 in. and 15 in. by 9 in. stroke would be appropriate to develop this power with good economy. Such an engine would, however, be rather large for your boat unless you wish to sacrifice all considerations for speed, and you might presumably do better to put in a smaller engine and be content with a moderate power, and the corresponding saving in coal. Thus for about 100 I. H. P. at 400 revolutions the sizes might be 5 3-4 in., 9 in. and 14 in. by 8 in. stroke, or for about the same power as you are now getting you could use 5 in., 7 1-2 in. and 11 1-2 in. by 8 in. stroke.

The full increase of power would probably add about 25 per cent to the speed of the boat, while 100 I. H. P. would probably add some 12 or 14 per cent. In any case, if the power is increased and revolutions kept the same, a new propeller would be required. If it were desired to retain the same propeller, the revolutions would have to be increased accordingly, and this would in turn change entirely the appropriate sizes of cylinders and stroke. The revolutions are already sufficiently high, and it is probable that the best results would be obtained by fitting a new propeller with the new engine.

Q.—I would thank you for any information you can give me about bilge keels. What effect would they have in steadying a vessel in a seaway? Would there be change of speed with bilge keels? What length and how wide a flange would a yacht, 98 ft. long on the water line, 13 ft. beam and 6 ft. draught, require to steady her in a seaway? S. H. D.

A.—Bilge keels, if properly fitted, may be expected to accomplish results somewhat as follows:

(1.) If the vessel were set rolling in still water with a given degree of roll, the bilge keels would reduce the number of sensible oscillations to perhaps one-third or one-fourth their number without the keels.

(2.) Among waves the bilge keels may be expected to reduce the extent of average roll to one-half or two-thirds its value without the keels. If the ship should fall in with waves of a period nearly the same as her own natural period of roll, the bilge keels will produce relatively less reduction in the extent of roll.

(3.) The period, or length of time occupied by a roll, is usually lengthened by an amount not far from 5 per cent.

(4.) These effects of bilge keels will be more pronounced as the midship section is more round, and less pronounced as it is more square or fuller on the bilge.

(5.) If properly fitted the keels will not affect the speed to an appreciable extent. Recent experiments show that presumably not more than two or three per cent. of the power is required to overcome the added resistance, and at moderate speeds, even less than this. The consequent effect on the speed would be less than one per cent.

(6.) Appropriate size of keels for a yacht such as the one you describe would be 50 to 60 feet long and from 9 to 12 inches wide. The effect will, of course, be more pronounced as the keel is wider.

Q.—I read with great interest the very clear explanation of boiler bracing in your last issue, and if you would add to this instructions how to figure out the safety valve problem, I believe you would interest, not only myself, but hundreds of other engineers. S.

A.—The arrangement of a weighted arm safety valve is shown in skeleton in Fig. 1. The steam presses upward on the lower face of the valve V, and is opposed by three forces tending to keep the valve on its seat as follows: (1) The weight of the valve and spindle direct. (2) The weight of the lever with center of gravity at some point N and pivoted at the fulcrum O. (3) The weight proper at M acting with a leverage or arm equal to $M\ O$.

Now just as the valve is about to open, these two sets of forces, the one acting upward and the other acting downward, will balance. It is furthermore a principle of mechanics that when such forces are just on a balance, the product of the

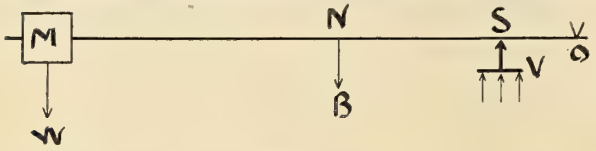


Fig. 1.

forces by their arms or leverages must make the same sum in each direction. Thus in the present case the up forces may be considered as tending to cause motion about the fulcrum O, and the down forces as tending to oppose motion about the same point. We therefore measure our arms from this fulcrum point O.

Now if A is the area of the valve in square inches and p the steam pressure in pounds per square inch by the gauge, the total steam load on the valve will be the product $p \times A$. This acts directly upward, and, as noted above, is directly opposed, as far as it goes, by the weight of the valve and spindle. Denote this by V. Then the difference $(p \times A - V)$ is the actual or net force transmitted from the valve to the lever at S, and thus tending to produce motion of the lever upward. Let a denote the arm for this force, or the distance $S\ O$ from the center of the spindle to the center of the fulcrum. Then $(p \times A - V) \times a$ is the product of force by arm for the upward forces. Let us save this and turn next to the remaining downward forces. Let W denote the amount of weight at M and l the arm or distance $M\ O$; also B the weight of the lever and c the arm $N\ O$ or distance from the center of gravity of the lever to the fulcrum. Then $W \times l + B \times c$ is the sum of the products for the downward forces. By condition these must be equal. Hence as an equation we shall have:

$$W \times l + B \times c = (p \times A - V) \times a$$

or

$$W \times l + B \times c = p \times A \times a - V \times a$$

From this equation we can find the value of any one quantity which we may wish, provided we know all the others. Thus suppose we know all but W. Then we have:

$$W = \frac{p \times A \times a - V \times a - B \times c}{l}$$

Similarly if we know all but l we have:

$$l = \frac{p \times A \times a - V \times a - B \times c}{W}$$

and if we know all but p, the pressure at which the valve will open with a given weight and location, we have:

$$p = \frac{W \times l + B \times c + V \times a}{A \times a}$$

We can readily express by rules the operations represented by these equations as follows:

Rule (1). To find the weight, knowing the other quantities.—Multiply together the pressure per square inch, the area of the valve in square inches, and the distance from the center of the valve spindle to the center of the fulcrum. From this

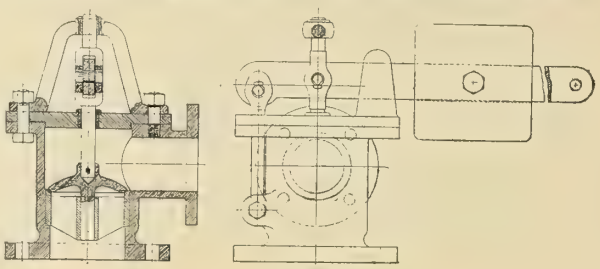


Fig. 2.

subtract the product of the weight of valve and spindle by the same arm $S\ O$, and also the product of the weight of lever by its arm $N\ O$. Divide the remainder by the weight arm $M\ O$, and the quotient will be the weight desired.

Rule (2). To find the location of the weight or length of arm $M\ O$, knowing the other quantities.—Find the same difference as in rule (1) and divide by the weight W. The quotient will be the length of the arm $M\ O$.

Rule (3). To find the pressure at which a given valve and weight will lift.—Multiply the weight W by its arm $M\ O$; also the weight of the lever by its arm $N\ O$, and the weight of the valve and spindle by its arm $S\ O$. Add these three products and divide the sum by the product of the area of the valve by the arm $S\ O$. The quotient will be the pressure desired.

Illustrative example:

Let $M\ O$ or l = 28 in.
" $N\ O$ or c = 12 in.
" $S\ O$ or a = 4 in.
" Diam. of valve = 3½ in.
Then Area of valve or A = 9.62 sq. in.
Let Weight of lever or B = 5½ lbs.
" Weight of valve or V = 4 lbs.
" Steam pressure or p = 80 lbs. per. sq. in.

Then,

$$p \times A \times a = 80 \times 9.62 \times 4 = 3078.4$$
$$V \times a = 4 \times 4 = 16$$
$$B \times c = 5\tfrac{1}{2} \times 12 = 66$$

Then,

$$3078.4 - 16 - 66 = 2996.4 \text{ and } W = \frac{2996.4}{28} = 107 \text{ lbs.}$$

in round numbers. Or if W were known and l required, we should find the same numerator, 2996.4, and then have:

$$l = \frac{2996.4}{107} = 28 \text{ in. in round numbers.}$$

Of if p is desired we should have:

$W \times l$		107	×	28	=	2996
$B \times c$	=	5½	×	12	=	66
$V \times a$	=	4	×	4	=	16
	Sum	- - - - - - - - -			=	3078
$A \times a$	=	9.62	×	4	=	38.48

We then have:

$$p = \frac{3078}{38.44} = 80 \text{ lbs. in round numbers.}$$

The U. S. regulations relating to safety valves will be found on pp. 36, 37 and 38 of the Rules Prescribed by the Board of Supervising Inspectors of Steam Vessels, issue of 1896, and you would do well to obtain a copy of these rules from the Supervising Inspector General of Steam Vessels, Treasury Department, Washington. You can then study up for yourself the details of the lever safety valve and fittings as therein prescribed, as well as the various rules and regulations relating to boilers, pumps, piping, etc., as prescribed by United States law.

The form and general proportions of lever safety valve recommended by the U. S. Board of Supervising Inspectors are shown in Fig. 2.

ENGINEERS' DICTIONARY.—V.

Boiling Point.—The degree of temperature at which boiling takes place. This varies with the pressure on the surface of the liquid, being at 212° on the Fahrenheit scale for atmospheric pressure, at 102° for 1 lb. pressure absolute or 13.7 lbs. vacuum, at 382° for 200 lbs. pressure, etc. Tables giving these temperatures are provided in text-books and hand-books relating to steam and the steam-engine.

Bonnet.—A small plate or cover closing the opening over a valve chamber and by its removal allowing the examination and repair of the valve. Also often used less exactly in reference to any small removable cover closing an opening.

Brace.—In general an auxiliary member intended to connect the principal members of a structure and to give them such support as they may need, additional to that provided by their own strength, as in the framing of an engine. See also under *Boiler.*

Brass.—As a material, an alloy of copper and zinc in about the proportions of two parts of copper to one of zinc. Its strength is not far from that of cast-iron, but it is much less brittle. It is much used where somewhat greater toughness is desired than can be furnished by cast-iron, and also where corrosion is sought to be avoided, and where its greater first cost is not a serious objection. It is also used to a considerable extent as a bearing metal. The two parts of a bearing, especially when of brass, are often called the upper and lower or *top* and *bottom brasses,* while together they are simply called the *brasses.* The same parts are also sometimes known as boxes, either referring to the bearing as a whole, or to the brasses alone.

Brazing.—The operation of joining two metals by means of *brazing solder,* or *hard solder,* as it is sometimes termed. The surfaces to be joined are cleaned, bound together with wire or otherwise, supplied with brazing solder in small bits mixed with borax as a flux, and placed in a clear fire until the alloy melts.

Brazing-Solder or *Hard-Solder.*—Usually a brass or alloy of copper and zinc, and so proportioned with regard to the metal with which it is to be used that the melting point of the latter is the higher of the two, in order to insure the melting of the solder without endangering the metals to be joined.

Brazed-Joint.—A joint made by brazing. All copper piping with its branches, tees, elbows, connections, etc., are made from sheet copper with brazed joints. The operation is one involving a considerable amount of skill, if done correctly.

Breeches Pipe.—A pipe separating into two legs or branches of equal size and running parallel or slightly diverging.

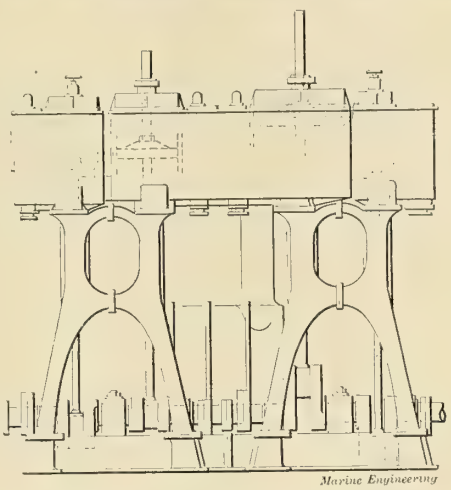
Bridge-wall.—See *Boiler.* A wall of fire brick placed at the back of the grate thus furnishing a back limit to the fire, and providing at this point a decrease in the size of the passage for gases into the combustion chamber. The object of this decrease, which is similar to the throat of an ordinary chimney, is to give to the products of combustion at this point a definite and pronounced velocity from the furnace to the combustion chamber.

Bridle-rods.—The term *suspension bar or rod* is a general name for any bar connecting the link of a Stephenson valve gear with the rock-shaft arm, and serving for its support and control as in reversing or linking up. *Bridle-rods* are a particular example of this mode of support in which they are two in number, one on either side with the link between. Often, however, the term is used more vaguely to denote any rod serving to support or control the link of a valve gear.

SELECTED PATENTS.

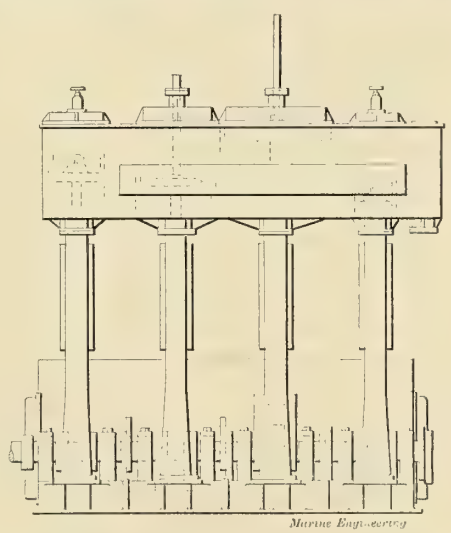
594,289. Balancing of Steam or Like Motive-Power Engines. *Ernst O. Schlick, Hamburg, Germany, assignor to the Yarrow, Schlick & Tweedy System, Limited, London, England. Filed Sept. 6, 1895.*

In a steam or like motive-power engine, the combination with the cylinders arranged side by side with their longitudinal axes at predetermined distances apart, and the moving elements of said cylinders,



namely their pistons and parts reciprocating therewith; of a shaft having four cranks acted upon by said moving elements set at different angles, the angular relation of said four cranks varying in accordance with and being determined by their length, the distances between them, the weights of the aforesaid moving elements and the finite length of the connecting-rods to balance the reaction forces acting upon the crank-shaft and engendered by the weight of said moving elements and resulting from the finite length of said rods.

In a steam or like motive-power engine, the combination with cylinders of different diameters arranged



side by side with their longitudinal axes at predetermined distances apart, and the moving elements of said cylinders, namely their pistons and parts reciprocating therewith; of a shaft having four cranks acted upon by the said moving elements set at differ-

ent angles, the angular relation of said four cranks varying in accordance with and being determined by their lengths, the distances between them, the weights of the aforesaid moving elements and the finite length of the connecting-rods to balance the reaction forces acting upon the crank-shaft and engendered by said moving elements and resulting from the finite length of said rods.

In a steam or like motive-power engine, the combination with cylinders of different diameters arranged side by side with their longitudinal axes at predetermined distances apart, the cylinders of greater diameter between those of less diameter, and the moving elements of said cylinders, namely their pistons and parts reciprocating therewith; of a shaft having four cranks acted upon by said moving elements set at different angles, the angular relation of said four cranks varying in accordance with and being determined by their lengths, the distances between them, the weights of the aforesaid moving elements and the finite length of the connecting-rods to balance the reaction forces acting upon the crank-shaft and engendered by said moving elements and resulting from the finite length of said rods.

In a steam or like motive-power engine, the combination with the cylinders arranged side by side with their longitudinal axes at predetermined distances apart, the moving elements of said cylinders, namely their pistons and parts reciprocating therewith and the valve-gears; of a shaft acted upon by said reciprocating elements and valve-gears and having four cranks set at different angles, the angular relation of said four cranks varying in accordance with and being determined by their length, the distances between them, the weights of said moving elements and valve gears and the finite length of the connecting-rods, to balance the reaction forces acting upon the crank-shaft and engendered by the weight of said parts and resulting from the finite length of the connecting-rods.

NEW PUBLICATIONS.

Gas, Gasoline and Oil Vapor Engines. By Gardner D. Hiscox, M.E. Norman W. Henley & Co., 132 Nassau street, New York. Second Edition. Size, 6 by 9 1-2. Pages, 365. With 270 Illustrations. Cloth, $2.50.

The second edition of this work, which has been very favorably received, is just out. It aims to give a complete knowledge of the theory and design, as well as the construction and operation, of internal combustion engines as displayed in American practice. This includes, of course, various types of engine of foreign invention manufactured here by arrangement with the original patentees. The greater part of the volume is taken up with matter relating to stationary engines, but there is considerable attention given to motors for boats and horseless carriages. Altogether it is a very useful book for the consulting engineer, as it contains within its covers matter which can only be had independently in the files of technical papers, and literature issued by many manufacturers, and in foreign works on the subject.

Marine Engineers *and How to Become One*, with Notes on the Board of Trade Examinations. By E. G. Constantine, M.I.M.E. The Technical Publishing Co., Ltd., Manchester, 1898. Size, 5 by 7½. Pages, 312. With Illustrations. Cloth, 5s.

The real purpose of this book is to inform any young man with a taste for sea service about the duties, responsibilities and opportunities of the seagoing marine engineer. It is written for British youth and so contains much matter which, though interesting enough, is not of material censequence to Americans. The subject is handled in an orderly way, commencing with an explanation of the British system of apprenticeship and concurrent scientific education, then follows a history of the marine engine, a series of chapters on the duties of the seagoing engineer, and a number of useful hints on the repair of breakdowns at sea, and finally much information about obtaining certificates from the British Board of Trade. The author's history of the marine engine, which deals principally with the Atlantic trade, is one of the best condensations of the subject we have read. There are a number of excellent illustrations in the text. The author has a good, clear style, and the book is of real interest throughout, and contains much information of value.

Reed's Useful Hints to Sea-Going Engineers, *and How to Repair and Avoid Breakdowns.* Also Appendices Containing Boiler Explosions. Useful Formulæ. Thomas Reed & Co., Sunderland. Third Edition, 1898. Size, 5 to 7 1-2. Pages, 248. With 42 Diagrams and 8 Plates. Cloth, 3s., 6d.

The publishers of this book are responsible for several really good, practical works on marine engineering subjects which have had a large sale. The "Useful Hints" is a very excellent example of their work. It is intended, as the title indicates, for sea-going engineers, who will, presumably, in the course of a voyage be far remote from any sort of workshop-facilities. The extensive instructions and illustrated suggestions for the treatment of breakdowns are especially valuable for men who are in such ships, but there is often need for considerable skill in cases of mishap in home waters. The various examples given are all the more valuable, as they are chiefly accounts of actual repairs effected on vessels, and not merely imaginative. No book could be published which would give instructions for all possible mishaps, no more than any book on operative surgery could adequately equip any surgeon for emergency work. Engines have a peculiar knack of giving out in the oddest places and ways imaginable, and not only this, but the conveniences and material for repair may differ vastly in different ships, even where the same sort of breakdown has to be handled. Besides the emergency work there are many pages of Useful Hints, when things are running smoothly, which can be read very profitably, especially by subordinates who expect to fit themselves for higher command. The book is extremely simple, practical and readable.

An official announcement of the death of Thomas F. Dowd, national secretary of the Marine Engineers' Beneficial Association, has been made by George Uhler, the national president, under date Chicago, May 21, in these words:

To the order wherever found, greeting:—With a feeling of profound sorrow, I announce the death from pneumonia, after an illness of only six days, of Brother Thomas F. Dowd, national secretary, at his home in this city at 9.30 A. M., Thursday, the 19th instant. It is not my desire at this time to enter into any detailed eulogy of the official life and services of our deceased brother, but with a sincere appreciation of his untiring zeal and interest in the affairs of the organization with which he has been officially connected for so many years, I simply make this brief announcement. The national president will be in Chicago for some days in connection with the office made vacant by the demise of our brother. Any important communications can be addressed to the Sherman House, Chicago. To fill out the unexpired term of our late Brother Dowd, I have this day appointed as National Secretary Brother George A. Grubb, of M. E. B. A. No. 4, whose address will be No. 1537 George street, Station B, Chicago, to whom all communications should be addressed, and to whom all remittances should be forwarded.

TRADE PUBLICATIONS.

"Why and How to Use Red Lead" is a pamphlet 6 by 9 in. in size and comprising 30 pages, issued by the National Lead Co., 100 William St., New York. It is written by Ralph K. Wing, who has made a special study of the subject in question.

Linenoid seamless boats and canoes are well illustrated and described in a 3 by 6 in. catalogue issued by Crane Bros., Westfield, Mass. These boats are made in various sizes and styles and any length up to 17 ft. Users of small boats will appreciate having one of these catalogues.

A patriotic panel in color entitled "Our Country's Standard" is received from the American Steam Gauge Co., 36 Chardon St., Boston, Mass. It is about 14 by 26 in. in size and represents a sailor lad hoisting the American flag, the flag being in colors and very well executed. Duplicates can be had upon application to the company.

Persons interested in water-tube boilers should send for a copy of the little pamphlet just issued by the Boyer Patent Sectional Water-Tube Boiler Co., 90 Wall St., New York. It gives three excellent illustrations of the boiler built by this company and installed on the steam freighter "Clara." The "deadly parallel" shows a remarkable efficiency of the boat with the new boiler.

The Palmer gas and gasoline engine is illustrated and described in a catalogue just received. The marine type is familiar to readers of Marine Engineering and is fully described in this catalogue. The catalogue also contains considerable information regarding the launches of various types sold by this company. Also a line of auxiliary appliances, such as propeller wheels, boat trimmings, etc.

The 1898 catalogue issued by the Lee-Penberthy Mfg. Co., Detroit, Mich., is just received. It is 5 by 8 in. in size and is a manual of useful and valuable information, comprising discount tables, pipe tables, railroad distances, and much other matter convenient for users, sellers, and manufacturers of steam goods. Several full-page illustrations are given of the Lee-Penberthy injectors manufactured by this company.

Sturtevant Engine Catalogue No. 103 is the latest publication by the B. F. Sturtevant Co., Boston, Mass. It comprises 45 pages, beautifully printed on coated paper, with a cover of rich dark green neatly embossed in light green and gold. The title to the catalogue tells the whole story of its contents, which include illustrations of the many types of this engine, with full descriptions, sectional drawings, and a great deal of valuable information which will interest every man who has to do with steam engines.

Two catalogues are received from the Weber Gas & Gasoline Engine Co., Kansas City, Mo. One of these is devoted to the engines manufactured by this company which are adapted to all kinds of uses in which small power is called for and the other one to the hoisting engines manufactured by this company. These hoisting engines have become very popular for use on wharves and docks, as well as on many vessels where any kind of hoist is required.

Marine specialties manufactured by the De La Vergne Refrigerating Machine Co., foot of East 138th St., New York, are fully described in a 40-page catalogue just received. These specialties include a line of hoisting engines designed for all uses, from small hoists up to large floating derricks. Various types are illustrated and fully described, and several tables give necessary sizes, prices, and other information. The hoists are either electric or steam, or can be operated by the Hornsby-Akroyd oil engine manufactured by this company. Another specialty which this company now handles is the Brownley injector.

BUSINESS NOTES.

OFFICE REMOVED.—William Craig, whose office was formerly at 42 Cortlandt St., New York, can now be found at 121 Liberty St., where full information can be obtained regarding his stop valve, feed-water circulators and other specialties.

BALL BEARING CO.'S NEW YORK OFFICE.—The Ball Bearing Co., Watson St., Boston, Mass., has been obliged, in order to secure improved facilities, to move its New York office from the American Tract Society Building to 121 Liberty st., where any information regarding roller and thrust bearings can be readily obtained.

MARINE ICE PLANTS.—The International Navigation Co. (American Line) has just ordered from the Kilbourn Construction Co., Drexel Building, Philadelphia, two refrigerating machines for use on one of its steamers. This makes thirty-six Kilbourn machines in use on the various boats of this line and is a high compliment to their efficiency.

COPPER TUBING.—Users of copper tubing will be interested in the picture shown in the advertisement of Randolph & Clowes, Waterbury, Conn., which gives some idea of the large sizes of tubing manufactured by this company. This company makes a specialty of condenser and other seamless copper tubes especially designed for marine work.

PIPE WRENCH.—The Brock pipe wrench, manufactured by J.H. Williams & Co., 9-31 Richards street, Brooklyn, N. Y., is a device that every engineer will value for use in his engine-room. The pictures of this wrench, shown in the advertisement of the company elsewhere in this issue, will show the design of this wrench and the grip that it must of necessity have.

HYDE WINDLASSES.—Many vessels recently constructed, both in the various departments of the Government and the merchant marine, as well as yachts, are introducing the Hyde windlass and capstan manufactured by the Hyde Windlass Company, Bath, Me. The fact that the people connected with this company are practically the same as those connected with the Bath Iron Works, the quality of whose workmanship is well known, is sufficient guarantee as to these windlasses and capstans.

COPPER COMPOUND COMPOSITION.—The anti-friction metal manufactured by the Standard Smelting Works, 172 Hudson St., New York, and known as their anti-friction metal copper compound, possesses many features of interest to users of such metal. A letter received by this company from the Chrome Steel Works of Brooklyn says: "We have used your composition on the pinion bearings of our 26 in. plate train, where it has been subjected to a thorough test, and will frankly say it has given better satisfaction than any metal we have heretofore used." The Standard Co. is prepared to send any information regarding this metal to all inquirers.

SEAMLESS STEEL TUBES.—The Shelby Steel Tube Company, Cleveland, Ohio, which has recently acquired the interests of a number of the largest seamless tube mills, both in Pennsylvania and Ohio, has secured a large contract from the United States Navy Department for boiler tubes. These tubes are of seamless cold-drawn steel, 21-4 in dia., by 9 gauge. All of the tubes are upset on one end. It is understood that this order comprises a full set of tubes for all of the boilers for the Iowa, Brooklyn, Cincinnati, Bennington, and a partial set for the Texas. These tubes are to be delivered within sixty days. The Shelby Steel Tube Company is thoroughly equipped for doing this class of work. This order is of interest, inasmuch as it is the first time in years that the Navy Department has taken steel tubes in preference to lap-welded charcoal iron tubes.

Graphite Lubrication

There is no substance known so smooth or so enduring as **Dixon's Pure Flake Graphite.** It is the best solid natural lubricant ever discovered. It is not affected by heat or cold, acids or alkalies. It is absolutely indispensable to every marine, stationary or locomotive engineer.

It will pay you to send for Sample and Pamphlet. No charge.

JOSEPH DIXON CRUCIBLE CO.,
JERSEY CITY, N. J.

REDUCING VALVES

to control or reduce steam, water or air pressures.

"MASON"

Valves have had a world-wide reputation for years.

Write for prices.

THE MASON REGULATOR CO.,
BOSTON, MASS.

THE SCHOOL FOR MARINE ENGINEERS,

AMERICAN SCHOOL OF CORRESPONDENCE.
(Chartered by Commonwealth of Massachusetts.)

TEACHES ONLY— **ENGINEERING** { STEAM, ELECTRICAL, MECHANICAL

OUR COURSES are Thorough and Practical. OUR INSTRUCTORS are Graduates of the Best Technical Schools. OUR ADVISORY BOARD Consists of Experts of World Wide Fame. OUR TERMS are Low and Within Reach of Every Wage Earner.

SPECIAL OFFER TO READERS OF "MARINE ENGINEERING."

33⅓% REDUCTION For the next 30 days we will give 33⅓% reduction **FOR 30 DAYS.**

from our regular tuition fee to all readers of MARINE ENGINEERING.

Write for hand-book of the school containing schedules of courses, names of instructors, pages from instruction papers, etc.

AMERICAN SCHOOL OF CORRESPONDENCE,
156 Tremont Street, BOSTON, MASS.

AN IMPROVED MEGAPHONE.—A seamless megaphone which is collapsible, like the drinking cups used by travelers, is just being put on the market by Crane Bros., Westfield, Mass. When not in use it makes a package the size and shape much like a silk hat case.

ACETYLENE SEARCH-LIGHTS. — Acetylene search-lights, designed with special reference for use on yachts and vessels of any kind, or wharves where a powerful light is wanted, are being put on the market by J. B. Colt & Co., 5 West Twenty-ninth street, New York. These lights are fully illustrated and described elsewhere, and circulars regarding them, giving considerable information, will be sent to all who wish them.

MARINE RAILWAYS.—With the great increase in marine work, the question of an efficient marine railway is an important one, and the value of special experience in this line will be much appreciated. A firm making a specialty of this work is H. I. Crandall & Son, East Boston, Mass. Marine railways designed under the Crandall patents are installed in many parts of the country, and any ship-yards contemplating adding a railway to its facilities would do well to consult this firm. A small-sized railway is well shown in this issue in the advertisement of this company.

MARINE INSTRUCTION.—The American School of Correspondence, 156 Tremont street, Boston, Mass., offers to marine engineers an excellent opportunity to secure a thorough and practical training in steam engineering. The school is conducted under the supervision of experts in steam engineering. Among the instructors and advisors of the school are Dr. Robert Grimshaw, George L. Fowler, Francis H. Boyer, and other authorities in the engineering field. The school makes a specialty of steam, electrical and mechanical engineering, and the instruction along these lines is unusually practical, thorough, and scientific. Write for their handbook.

INJECTORS AND BRONZE CASTINGS.—The Eynon-Evans Manufacturing Company, Philadelphia, Pa., has been kept very busy this spring by the increased demand among the boat-builders for its Eynon-Korting compound injector. Among the many purchasers of this injector are: William Cramp & Sons and Charles Hillman Company, of Philadelphia; the Maryland Steel Company, of Baltimore, Md.; the Delaware River Iron Shipbuilding and Engine Company, of Chester, Pa.; Harlan & Hollingsworth, of Wilmington, Del.; Charles D. Mosher, of New York City; New Bedford Boiler and Machine Company, New Bedford, Mass.; United States Navy-Yard at Port Royal, S. C., and the United States Navy-Yard at League Island, Philadelphia. This company has also been doing a great deal of work in high-grade bronze castings for the disappearing gun carriages for the United States Government, also propeller wheels, bearings, sleeves, etc., in phosphor and manganese bronze.

LUBRICATION OF GAS ENGINE CYLINDERS.—The proper lurication of gas-engine cylinders has been a difficult problem. The problem, however, seems to have been very successfully solved by an official of the Pennsylvania Railroad Company, who writes: "I had a gas engine, and the man that had charge of it allowed the lubricator to run dry and cut the piston, piston rings, and cylinder. The makers of the engine said the cylinder would have to be sent to the shop and bored out and a new piston put in. It was our busy season, and we could not do without water. I had some of Dixon's finely pulverized graphite, and I commenced to feed it into the cylinder through the suction-pipe with the air and gas, with immediate relief. After about two weeks the engine was running smoother and using less gas than ever before. I had this same engine apart last Saturday, and every place that was cut is smooth as glass. This one instance saved us about $75. I have great faith in this graphite, and always keep it on hand."

FLANGE UNIONS.—One of the improved devices being put on the market by the E. M. Dart Manufacturing Company, Providence, R. I., is a flange union which is used without packing. These unions are made of bronze metal, have ball-bearing seats, and will make a tight and durable joint out of alignment.

CORRUGATED TUBE SURFACE CONDENSERS.—The several appliances manufactured by the Taunton Locomotive Manufacturing Company, Taunton, Mass., for marine work include corrugated tube surface condensers. These are made in all sizes from 50 to 10,000 sq. ft. of cooling surface, and are fully illustrated and described in a catalogue issued by the company. A second-hand condenser is offered for sale by this company, as will be seen among Special Notices.

GOOD STEAMING COAL.—The value of Toms Creek coal for bunker purposes is well emphasized in a letter received by the Toms Creek Coal and Coke Company, Norfolk, Va., from the master of the English steamship Blenheim, who says: "I have had experience of nearly all the various brands of steam coal supplied to steamers of the North Atlantic seaboard. I can conscientiously state that your Toms Creek coal is quite equal to the best, both as regards steaming qualities and economy."

ELECTRICAL EQUIPMENT.—The Sprague Electric Co., 20 Broad St., New York, report an immense increase in business, and the large factory on West 34th St. is now running nights as well as days to supply the demand for Interior Conduit and Lundell dynamos and motors. This Conduit is being used on many of the new Government vessels as well as on private yachts, and the capabilities of the Lundell dynamos and motors have long been established. The new auxiliary vessel "Gloucester," formerly J. P. Morgan's beautiful yacht 'Corsair," is fully equipped with Sprague apparatus.

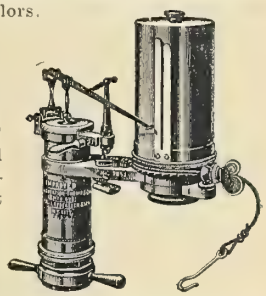
SEND 2 LABELS

cut from front of boxes of EUREKA PACKING and we will send you a pack of beautiful playing cards. All being special in 3 colors.

MARINE ENGINEERS

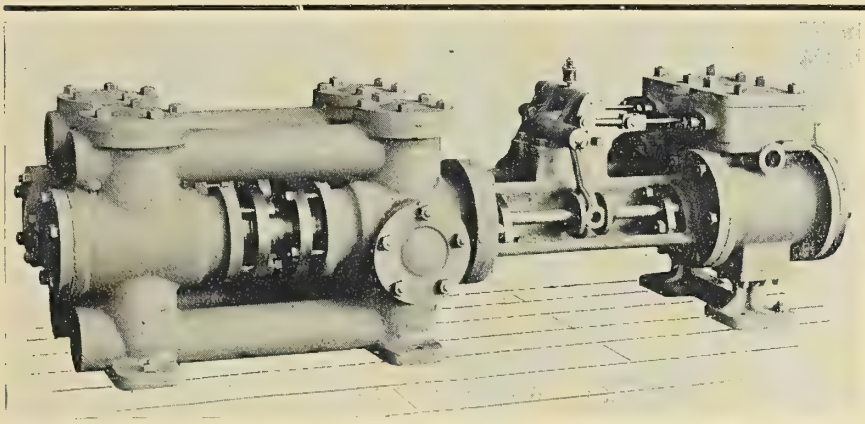
should own an INDICATOR and know how to use it. Send for circular and *special* prices. It will interest you.

Jas. L. Robertson & Son,
218 Fulton St., N. Y.



ANTI-FRICTION METALS.—The great increase in the Volume of marine business has shown a marked difference in the shops of Caskey Bros., Newport News, Va. The demand for Caskey's manganese bronze white packing metal has increased with business, and this company is now supplying large quantities for many of the new vessels built both for private parties and for the Government.

CAPTAIN M. DE PUY, the inventor of the improved leg boiler known as the "Paragon," has decided to build a new Erie Canal steamer, to be fitted with his boiler and a 14 in. by 16 in. low pressure engine. In the canal the boat will carry 160 tons, and in the harbor and sound trade, 250 tons. The hull and engine will be built at Lockport, N. Y., and the boiler by Riter Bros., Buffalo, N. Y. The dimensions of the boiler will be 6 ft. 6 in. wide, 8 ft. long, and it will have 254 2 1-2 in. tubes 6 ft. long.



THE HUGHES IMPROVED DUPLEX PLUNGER PUMPS

Are extra strong, compact and durable. They are externally packed and are particularly well adapted for marine service. Catalogue showing different styles will be sent on application.

THE SNIDER-HUGHES CO., COE AND HAMILTON STREETS, CLEVELAND, O.

The Francis Tool

PATENTED MAY 25TH, 1897.

It has no Screws.
No Slipping.
Made of Wrought Steel.
Cutter Easily Removed.

Write for Prices, etc.

THE UNITED STATES METALLIC PACKING COMPANY,
SOLE AGENTS AND MANUFACTURERS,
429 NORTH 13th STREET, PHILADELPHIA, PA.

A Popular Marine Closet.—The "Neptune" single lever closet recently put on the market by McCambridge & Co., Ltd., 523-527 Cherry St., Philadelphia, has become very popular and is one of the best selling devices manufactured by this company.

Watson Radial Water-Tube Boiler.—This new water tube boiler, which is just being put on the market by Egbert P. Watson, Elizabeth, N. J., is described briefly, but with much force, in the advertisement elsewhere. It is made in sizes from 3-horse power upwards, and is designed for any pressure. Mr. Watson's years of connection with marine matters will be of much value to him in introducing this new invention.

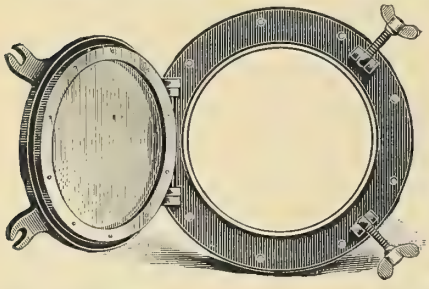
Marine Forgings.—The well-known plant formerly known as the Central Forge Co., at Whitestone Landing, L. I., has been purchased by a new company known as the Whitestone Forge and Construction Co. The plant has been thoroughly overhauled and fitted with the latest improved devices, and is prepared to fill orders for all classes of iron and steel forgings. The New York office of the company is at 11 Broadway, where full information can be secured.

A New Belting.—The question of satisfactory belting is a serious one in shipyards and manufacturing establishments where power is transmitted by this means. In order to satisfy the demand for such belting the Boston Belting Co., 256 Devonshire street, Boston, Mass., is offering its Gutta-Ballata belting. It is seamless and can be run with either side next the pulley, does not deteriorate with age, is not affected by oil or grease, and has many other qualities, set forth in a folder which can be had upon application to the company.

Engineers' Supplies.—We are informed by James L. Robertson & Son, 218 Fulton St., New York, that many of the U. S. war vessels carry a full stock of Eureka packing. This is a compliment which the manufacturers should appreciate. Another specialty of this company which is proving very popular is the Robertson-Thompson indicator, which has many distinct features in its construction and yet is sold at such a low price as to be within the reach of almost any engineer. Full information regarding either of these specialties can be had by applying to the manufacturers.

Electric Power.—The Bullock Electric Mfg. Co., Cincinnati, Ohio, has lately issued a small card which is enclosed in all letters. On one side is displayed a cut of one of the company's motors operating a 72-in. planer. The shaft of the motor is coupled direct to the main driving shaft of the planer. The motor is of small size and is placed on top of the planer, allowing a traveling crane to pass over it. The motor is shunt wound to give constant speed under varying loads, and has a capacity of 12 horse power. On the other side of the card is a short description of the arrangement of motors on machine tools and advantages to be derived from this mode of supplying power. The card is printed in two colors and makes a neat enclosure.

VESSEL MACHINERY AND SUPPLIES.



Windlasses, Captans, Pumps, Steering Apparatus.

Marine Monitor Side Lights.

Contractors' Supplies.

Shipbuilders' Supplies.

Oakum, Caulking Cotton, Deck Plugs, Pitch, Tar.

General Line of Ship Chandlery, Marine Hardware, Cordage, Wire Rope, Yacht Supplies, Flags, Signals, etc.

Marine Manufacturing & Supply Co., 158 South St., New York.

SPECIAL NOTICES.

Announcements under this heading will be inserted at the uniform rate of thirty-three-and-a-third cents a line. Lines average ten words each.

A KLONDYKE MINE RIGHT HERE.

It is in the new patent Paragon Marine Boiler, illustrated and advertised elsewhere. Half interest or State rights for sale. Address Capt. M. De Puy, 49 South St., New York.

SURFACE CONDENSER FOR SALE.

A surface condenser with 1,816 sq. ft. of cooling surface nearly new, for sale cheap. For full particulars write to the Taunton Locomotive Manufacturing Company, Taunton, Mass.

EXPERIENCED ENGINEER DESIRES POSITION.

Marine engineer, 16 years' experience in shop and drawing room, desires position; has handled men. Address W., care Marine Engineering.

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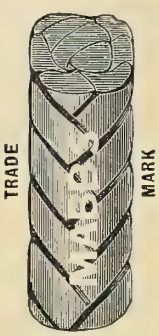

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